EXHIBIT 3

TRINITY RIVER FLOW EVALUATION

Final Report

A report to the:

Secretary
U.S. Department of the Interior
Washington, D.C.

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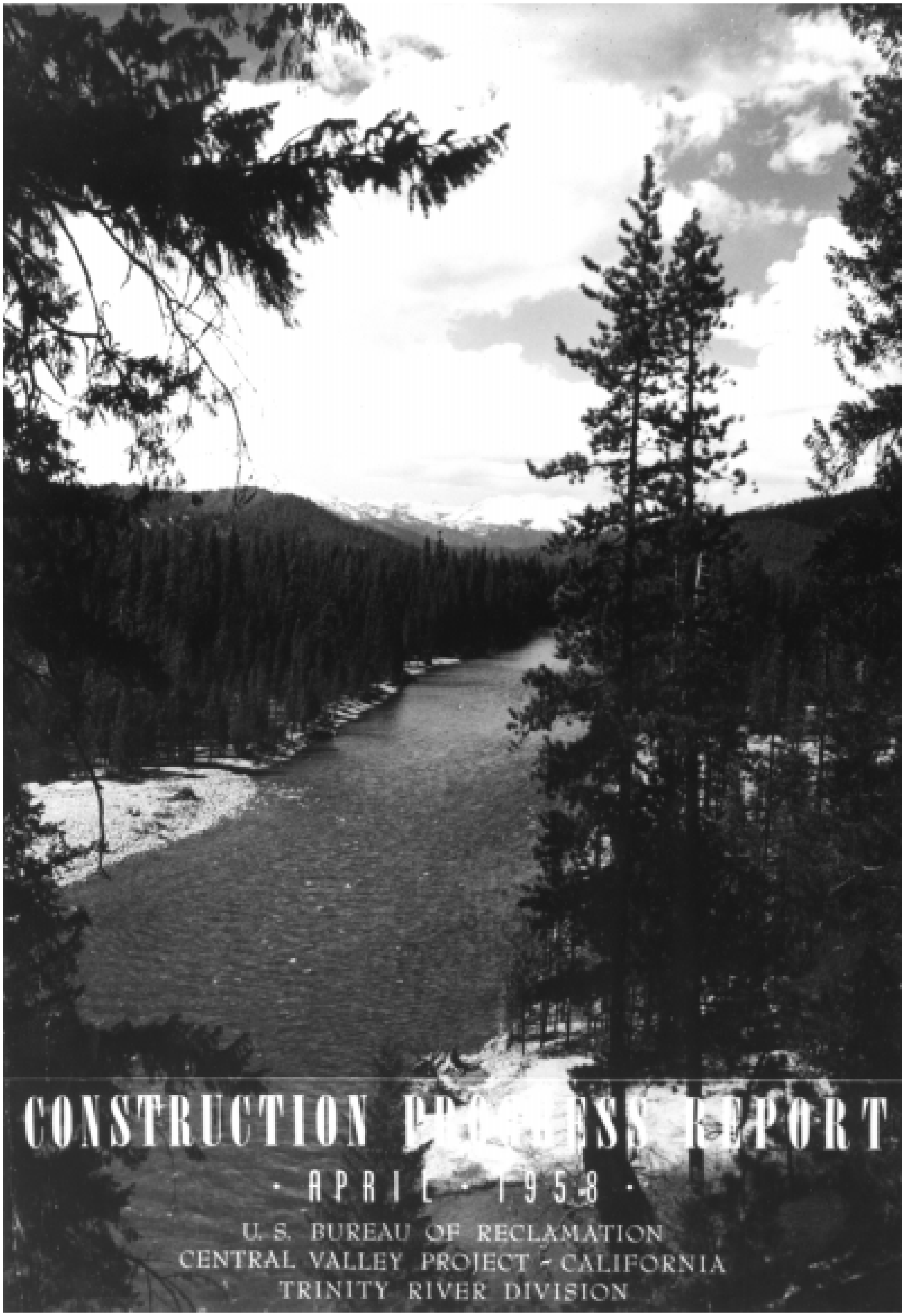
CONSTRUCTION PROGRESS REPORT
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U. S. BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT - CALIFORNIA
TRINITY RIVER DIVISION

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EXECUTIVE SUMMARY

When Congress authorized construction of the Trinity River Division (TRD) of the Central Valley Project (CVP) in 1955, the expectation was that surplus water could be exported to the Central Valley without harm to the fish and wildlife resources of the Trinity River. The TRD began operations in 1963, diverting up to 90 percent of the Trinity River's average annual yield at Lewiston, California. Access to 109 river miles of fish habitat and replenishment of coarse sediment from upstream river segments were permanently eliminated by Lewiston and Trinity Dams. Within a decade of completing the TRD, the adverse biological and geomorphic responses to TRD operations were obvious. Riverine habitats below Lewiston Dam degraded and salmon and steelhead populations noticeably declined.

In 1981, the Secretary of the Interior (Secretary) directed that a Trinity River Flow Evaluation (TRFE) study be conducted to determine how to restore the fishery resources of the Trinity River. This report is the product of that TRFE study. It provides recommendations to the Secretary to fulfill fish and wildlife protection mandates of the 1955 Act of Congress that authorized the construction of the Trinity River Division of the Central Valley Project, the 1981 Secretarial Decision that directed the U.S. Fish and Wildlife Service to conduct the TRFE, the 1984 Trinity River Basin Fish and Wildlife Management Act, the 1991 Secretarial Decision on Trinity River Flows, the 1992 Central Valley Project Improvement Act, and Federal Tribal trust responsibilities.

This report was compiled by teams of experts. After research and literature reviews were completed, they met to discuss the collective implications of their work. Individual chapters were then written and reviewed as a group. The purpose of each chapter was to:

- describe Congressional, Secretarial, and other actions taken to address the declines of the Trinity River fishery resources (Chapters 1 and 2);
- present the pre- and post-TRD biological and physical scientific knowledge of the Trinity River, including salmon and steelhead life histories and population trends, and changes in channel morphology and overall quality of fish habitat (Chapters 3 and 4);
- present the findings of studies conducted as part of the TRFE and the Trinity River Fish and Wildlife Restoration Program (Chapter 5);
- evaluate the effectiveness of the water volumes identified in the 1981 Secretarial Decision to restore fishery resources (Chapter 6).

The collective scientific effort led to:

- the conclusion that a modified flow regime, a reconfigured channel, and strategy for sediment management are necessary to have a functioning alluvial river (mixed-size rock, gravel, and sand deposited by river flow) that will provide the diverse habitats required to restore and maintain the fishery resources of the Trinity River (Chapter 7);
- instream flow, channel-rehabilitation, and fine and coarse sediment recommendations to address this conclusion (Chapter 8); and
- a recommendation to utilize an Adaptive Environmental Assessment and Management (AEAM) approach to guide future management and ensure the restoration and maintenance of the fishery resources of the Trinity River (Chapter 8).

Life History and Physical Requirements

The life histories of steelhead (*Oncorhynchus mykiss*), coho salmon (*O. kisutch*), and chinook salmon (*O. tshawytscha*) have two distinct phases, one in freshwater and the other in salt water. These species lay their eggs (spawn), hatch, and rear in freshwater. The adults lay their eggs in gravel of various preferred sizes (depending on species). The eggs incubate in the spaces between rocks of the river bed. After a period of time, small, fully formed fish ("fry") emerge from the gravel to begin their free-swimming life-stages. Young salmonids remain in the river of their birth for months to years (depending on species) before migrating to the ocean. Before they migrate, they undergo a physiological transformation (called smoltification) that allows them to survive in a saltwater environment. At that point, they are called "smolts". After the transformation, they migrate to saltwater. Salmon grow to their adult size in the ocean, returning in 2 to 5 years to the river of their birth to spawn.

Steelhead, coho salmon, and chinook salmon each require similar instream habitats for spawning, egg incubation, and rearing, although there are important differences. Timing of these habitat needs varies, thus optimizing population numbers and survival by minimizing competition among species. Common life-history requirements for these species include spawning gravels relatively free of fine sediments, adequate spawning habitat, low-velocity shelters for early life-stages, adequate rearing and feeding habitats with cover from predators, and appropriate flows and temperature conditions for migration to and from the ocean. For all species, spawning occurs in tails of pools and riffles where gravels are cleansed of fine sediment by high flows. Eggs and embryonic life stages develop in these well-percolated gravels for weeks until emerging as fry, which seek shallow, low-velocity shelters usually found along channel margins of gently sloping point bars and backwater areas. As they grow, habitat requirements change to faster and deeper riffle, pool, and run habitats, depending on the species. The habitats necessary for salmonids to complete all of their freshwater life stages were provided in the pre-TRD riverine environment; however, these conditions were radically changed by the operations of the TRD.

Changes of Riverine Habitats and Fish Populations Resulting from Construction and Operation of the TRD

Prior to the construction of the TRD, the Trinity River was an unregulated, meandering, dynamic alluvial river within a broad floodplain. Alluvial means "material deposited by running water." Dynamic means "that the alluvial material was frequently moved and the channel moved back and forth across the floodplain over time". Alluvial rivers are often characterized by a repeated, distinctive S-shaped channel pattern that is free to meander in the floodplain (alternate bar sequences). High flows periodically changed the size, shape, and location of river bars (submerged or exposed alluvial material). Flow regulation by the TRD removed nearly all high flows that were responsible for forming and maintaining dynamic alternate bar sequences. No longer scoured by winter floods downstream of the TRD, streambank (riparian) vegetation encroached into the river channel and formed riparian berms along the channel margins. Reduced flows, loss of coarse sediment, and riparian encroachment caused the mainstem river downstream from the TRD to change from a series of alternating riffles and deep pools that provided high-quality salmonid habitat to a largely monotypic run habitat confined between riparian berms (a trapezoid-shaped channel). The loss of alluvial features and diverse riverine habitats reduced the quantity and quality of salmonid habitats and the populations that relied upon them.

The available data indicate that in-river spawning populations of salmon and steelhead have dramatically declined since the construction of the TRD (Table ES1). Average spawning numbers of post-TRD naturally produced spring-run (return to the river in the spring) and fall-run (return to the river in the fall) chinook salmon represent a 68 percent reduction compared to the pre-TRD average. Large numbers of returning chinook salmon spawners observed since 1978 were typically hatchery-produced fish. Naturally produced fall- and spring-run chinook salmon account for an average of 44% and 32% of their respective spawning runs. This situation is not indicative of healthy spawning and (or) rearing conditions for naturally produced populations. The inriver coho salmon spawning population is predominantly of hatchery origin, with only 3 percent of the spawning coho attributable to natural production. While naturally produced fall-run steelhead make up a large portion of the inriver spawners (70 percent), this still represents a 53 percent reduction from pre-TRD estimates.

Table ES1. Pre- and Post-TRD Adult Salmon Returning to Spawn

Species	Pre-TRD Average[1]	Post-TRD Average for Naturally Produced Spawners[1]	Percent Reduction
Chinook Salmon (Spring-Run/Fall-Run)	38,600[2] (not available)	12,550 (1,550/11,000)	67%
Coho Salmon	5,000	200	96%
Steelhead	10,000	4,700	53%

[1] Pre- and Post-TRD adult salmon return data is presented in Chapter 3.

[2] Pre-TRD average number of chinook salmon returning to spawn was reduced by 9,000 to make pre- and post-TRD numbers more comparable, (i.e. the fish production that previously was provided above Lewiston and is included in the pre-TRD average of 47,600 chinook is now provided by the TRFH (returning adult requirements to provide eggs for the hatchery are 3,000 spring-run chinook and 6,000 fall-run chinook)).

Coho salmon that return to Klamath and Trinity Rivers are considered by the National Marine Fisheries Service (NMFS) to be part of the Southern Oregon/Northern California Coast Evolutionary Significant Unit (ESU) — one population for Federal Endangered Species Act (ESA) purposes. This ESU has been listed as threatened pursuant to the ESA. The final rule that listed the ESU recognized that various habitat declines affected coho salmon populations, including channel morphology changes, substrate changes, loss of off-channel rearing habitats, declines in water quality, and altered streamflows. The steelhead and chinook salmon populations of the Trinity River are being evaluated pursuant to the ESA and may warrant listing in the future.

Although the primary focus of this report is salmon and steelhead, pre-TRD wildlife populations have also been affected by changes in the riverine environment. Wildlife habitat features such as seasonally flooded marshes and side channels, shallow river margins, cold-water holding pools, and bank undercuts have been reduced or eliminated owing to TRD operations. Species that depend on flood-maintained habitats, such as the foothill yellow-legged frog (*Rana boylii*) and the western pond turtle (*Clemmys marmorata*), have been negatively impacted by TRD construction and operations.

Flow Evaluation Studies and Results

Several individual studies provided the needed information to make the recommendations in this report: (1) habitat preferences of salmon and steelhead and relative amounts of preferred habitats resulting from varying dam releases; (2) an evaluation of habitat availability and channel processes at channel-rehabilitation projects; (3) water and sediment interactions and river channel shape (fluvial geomorpholgy); (4) water temperature needs of salmon and steelhead and dam releases necessary to meet those needs; and (5) a juvenile salmon production model. The results of these studies are summarized below.

A study of the physical conditions (such as water depth, velocity, and structural elements) that support specific anadromous salmonid life stages (microhabitat) resulted in the development of site-specific habitat suitability criteria. Using these criteria, the relation between microhabitat and streamflow for riverine life-stages of chinook salmon, coho salmon, and steelhead were modeled. Results of physical habitat availability modeling on the Trinity River were used as a partial basis for making instream flow recommendations in conjunction with information on pre-TRD hydrology, fluvial geomorphology (streamflows needed to form and maintain the channel), sediment management, and water temperatures.

Several channel rehabilitation projects were evaluated to determine if these projects created the shallow, low velocity habitats required by young salmon and steelhead for rearing. Results indicated that restoring the gradually sloping bars provided stable amounts of rearing habitat throughout a wide range of flows - an improvement over conditions in the existing channel where the amount of available habitat fluctuates widely over the same range of flows. Rehabilitating the confined, trapezoidal channel to restore the pre-TRD channel morphology will provide high quality, stable habitat conditions that should greatly benefit young salmon and steelhead until they are ready to migrate to the ocean.

TRD operations disrupted the water and sediment interactions of the river, which changed the fish habitats below Lewiston Dam. To rehabilitate the complex habitats that were similar to those that existed in the pre-TRD alluvial channel, pre- and post-TRD water and sediment interactions were examined to determine what pre-TRD processes are absent in the post-TRD river and how these processes can be re-established. These processes are largely defined by a set of ten fundamental alluvial river attributes. These attributes are: (1) the channel morphology is spatially complex; (2) flows and water quality are predictably variable; (3) the channel-bed surfaces are frequently mobilized; (4) the channel-bed surfaces are periodically scoured and refilled; (5) fine and coarse sediment supplies are approximately balanced; (6) the channel location periodically migrates; (7) the channel has a functional floodplain; (8) the channel is occasionally "reset" during very large floods; (9) riparian plant communities are diverse and self-sustaining; and (10) the groundwater table (subsurface water level that surrounds rock, gravel and sand along the side of the river) fluctuates naturally with changing streamflows. Studies were conducted to identify dam releases required to re-establish the processes necessary to achieve many of these attributes (called fluvial geomorphological processes). Recovering the dynamic alluvial channel morphology similar to that which existed pre-TRD will restore the diverse habitats needed by the fish and wildlife.

Water temperature affects every aspect of the life of salmonids, including egg incubation, growth, maturation, competition, migration, spawning, and resistance to parasites, diseases, and pollutants. Operations of the TRD changed the thermal regime of the Trinity River, providing warmer water temperatures during the winter and colder water temperatures at Lewiston during the late spring/summer than were present at Lewiston prior to the TRD because water is released from the deep levels behind the dam. It was generally believed that the TRD would increase salmonid production due to more stable flows and cooler summer water temperatures provided by dam releases. This increased production was never realized. Most salmonid smolts outmigrated before summer water temperatures were unsuitable. Rearing juvenile salmonids remained in the cooler riverine habitats above Lewiston that were predominantly fed by snowmelt, or sought the cool layer of water at the base of pools throughout the mainstem (a stratified pool). Operation and construction of the TRD blocked these upstream habitats and altered flows such that pools no longer stratify. Temperature objectives were established for the Trinity River that are, in effect, to compensate for the loss of these necessary cool-water habitats. In order to examine the dynamic relation between meteorology, tributary hydrology, dam release temperatures and release magnitudes that all influence downstream water temperatures, a temperature model (SNTEMP) was calibrated specifically for the Trinity River. This model was used to examine water temperatures under various conditions and to help determine what flows were necessary to meet temperature objectives for outmigrating salmon during the spring and early summer. Simulations and measured data show that water temperatures throughout the Trinity River are influenced by dam releases during the spring. Increasing dam releases during the spring and early summer can improve temperature conditions in the river that promote better growing conditions and increase survival for ocean bound, outmigrating smolts. Because spring- and fall-run chinook salmon require cold water to survive and successfully spawn, but can no longer access cold-water areas above Lewiston Dam, there is a need to maintain a cold-water segment below Lewiston Dam. Dam releases can be effectively managed to provide holding areas that are the proper temperature for adult salmon and steelhead during the summer, fall, and winter.

A model, SALMOD, was developed to evaluate the effect of varying environmental conditions (flows, water temperature, habitat availability) on the number of naturally produced young-of-the-year chinook salmon in the Trinity River from Lewiston Dam downstream 25 miles. This model evaluated the potential numbers of fish (young-of-the-year chinook as an index) that could be produced under the four water volumes identified in the

1981 Secretarial Decision. In general, model results indicated that: (1) habitat conditions in the current channel severely limit the salmonid production potential of the Trinity River; and (2) increased rearing habitat is critical to restore and maintain salmonid populations.

Evaluation of the 1981 Secretarial Decision Volumes

The 1981 Secretarial Decision identified four volumes of water for evaluation: 140 thousand acre-feet (TAF), 220 TAF, 287 TAF, and 340 TAF. One acre-foot of water is the volume of water that would cover one acre to a depth of one foot (approximately 326,000 gallons - an average household uses between one-half and one acre-foot of water per year). Release schedules developed for each of the water volumes were assessed for their ability to meet criteria necessary to restore and maintain the fishery resources of the Trinity River: fish habitat requirements, summer/fall temperature criteria, smolt outmigration temperature requirements, and thresholds for geomorphological processes that create and maintain diverse fish habitats (alluvial river attributes). The flow releases from Lewiston Dam required to meet the criteria and accomplish specific objectives are described below:

1. Year-round releases of 300 cfs to provide suitable spawning and rearing habitat for salmon and steelhead within the existing channel;

2. Releases of 450 cfs from July 1 to October 14 to meet the summer/fall temperature objectives;

3. Spring/summer releases that would provide improved conditions for smolt outmigration; and

4. Releases necessary to achieve flow-related geomorphic processes that create and maintain river habitats.

The volumes of water identified in the 1981 Secretarial Decision were able to meet the fishery restoration criteria in varying degrees, although all criteria are not fully met even with the greatest volume, 340 TAF. The current water volume of 340 TAF is equal to the third driest year in the 84-year period of record at Lewiston, indicating that the river below Lewiston Dam has experienced a functional 35-year drought since TRD operations began. Habitat degradation and fine sedimentation, identified as reasons for the decline of these fishery resources, will continue under all 1981 Secretarial Decision volumes because of lack of sufficient water to address multiple needs within a single year. SALMOD results showed that peak production of chinook salmon will be reached at water volumes above those identified in the 1981 Secretarial Decision.

Fishery Restoration Strategy

The recommended strategy to rehabilitate salmonid habitat is a management approach that integrates riverine processes and instream flow-dependent needs. A fundamental conclusion of this and other studies is that the present channel morphology, a direct result of TRD construction and operation, is inadequate to meet salmonid production objectives. If naturally produced salmonid populations are to be restored and maintained, the habitats on which they depend must be rehabilitated.

Recommended future management to restore the fishery resources of the Trinity River must include reshaping selected channel segments, managing coarse and fine sediment input, prescribing reservoir releases to allow flow-related geomorphic processes to reshape and maintain a new dynamic channel condition, providing suitable spawning and rearing microhabitat, and providing favorable water temperatures for salmonids. This new channel morphology will be smaller in scale than that which existed pre-TRD, but it will exhibit the essential attributes of a dynamic alluvial river.

Recommendations

Rehabilitation of the mainstem Trinity River can best be achieved by restoring processes that provided abundant complex instream habitat prior to construction and operation of TRD. Restoring these processes requires releasing increased annual instream volumes in conjunction with variable reservoir release schedules, managing fine and coarse sediment supplies, and rehabilitating selected reaches of the mainstem channel. Studies performed as part of the TRFE identified three sets of flow-related management objectives: (1) releases to provide suitable

salmonid spawning and rearing habitat; (2) releases to mimic the spring snowmelt hydrograph (the high flow in the spring resulting from the melting snowpack and the gradual decrease in flow following the peak) to satisfy flow-related geomorphic and riparian vegetation objectives necessary for the creation and maintenance of diverse salmonid habitats and assist smolt outmigration; and (3) releases to meet appropriate water-temperature objectives for holding/spawning adult salmonids and outmigrating salmonid smolts. Together, these recommended actions will rehabilitate the mainstem channel below Lewiston and provide the habitats necessary to restore and maintain the fishery resources of the Trinity River.

Water-Year Classification and Annual Instream Water Volumes

Variability is a keystone to the restoration strategy because no single annual flow regime can be expected to perform all functions needed to maintain an alluvial river system and restore and maintain the fishery resources. There are five water-year classes used in this study to describe the variability expected from year to year. They are Critically Dry, Dry, Normal, Wet, and Extremely Wet. In the restoration strategy outlined in this report, various flow-related geomorphic objectives and desired habitat conditions (microhabitat and temperature objectives) are targeted for each water-year class. Some processes and habitat conditions, such as favorable spawning and rearing microhabitat, are recommended for all water-year classes while others, such as floodplain inundation, are expected to be achieved only during the wetter water-year classes. Annual release schedules were developed by integrating the information on requirements to meet spawning and rearing microhabitat, flow-related geomorphic processes, and water temperature management objectives for the different water-year classes.

Inter-annual flow variability is achieved by recommending unique annual flow releases for each water year class. Recommended total instream water volumes range from 368.6 TAF in Critically Dry water years to 815.2 TAF in Extremely Wet water years (Table ES2). The average (weighted by water year class probability) water volume required for the Trinity River will be 594.5 TAF, an average increase of 254.5 TAF over the current water volume of 340 TAF.

Within Year (Seasonal) Flow Recommendations

Intra-annual changes in flow are often described by water managers, hydrologists and other scientists by a seasonal hydrograph. Flow levels fluctuate throughout the year based on weather conditions or managed water releases. The following summary is a description of recommended water releases from Lewiston Dam and the expected benefits downstream from the dam. The described seasonal water releases of the total water volume assigned to each water-year class are graphically depicted in Figure ES1.

In the present Trinity River channel, maintaining 300 cfs as the fall/winter baseflow provides suitable spawning habitat throughout the chinook salmon, coho salmon, and steelhead spawning seasons and provides habitat for rearing salmon and steelhead.

Since flow-related geomorphic management objectives require various flow levels, more comprehensive changes occur during wetter years. A list of the expected objectives that can be met by releases during the spring snowmelt hydrograph in different water-year classes is depicted in Table ES3. The short, 5-day, peak release during all water-year classes (except Critically Dry) provides sufficient duration to initiate targeted flow-related geomorphic processes and transport coarse bed material originating from tributaries in most years. The timing of the spring snowmelt peak release varies on the basis of historical timing, with the peak occurring later during wetter water years. The magnitude of releases to achieve flow-related geomorphic processes targeted for each water-year class varies, ranging from 1,500 cubic feet per second (cfs) in Critically Dry water years to 11,000 cfs in Extremely Wet water years. The recommended Extremely Wet and Wet spring snowmelt hydrographs also have two distinct segments while flows are decreasing after the spring snowmelt peak flow (referred to as the "descending limb of the spring snowmelt hydrograph"). These periods are separated by a short-duration "bench" at 6,000 cfs. The "bench" promotes transport of fine sediment once peak flows have mobilized the surface layer of the channelbed. Another "bench", at 2,000 cfs, is recommended for Extremely Wet, Wet, and Normal water years to inundate portions of alternate bars during the time period when riparian vegetation releases seeds. This inundation

Table ES2. Recommended annual water volumes for instream release to the Trinity River in thousands of acre-feet (TAF), probability of occurrence, and Trinity Reservoir inflow thresholds.

Water-Year Class	Instream Volume (TAF)	Trinity Reservoir Inflow (TAF)	Probability of Occurrence
Extremely Wet	815.2	>2,000	0.12
Wet	701.0	1,350 to 2,000	0.28
Normal	646.9	1,025 to 1,350	0.20
Dry	452.6	650 to 1,025	0.28
Critically Dry	368.6	<650	0.12
Average (weighted by water-year probability)	594.5		

prevents riparian encroachment along the low-flow channel and provides suitable temperatures for chinook salmon smolts, which outmigrate later in the year than other salmonid species. A 36-day, 1,500-cfs "bench" during Critically Dry water years will discourage seedling germination on alternate bar flanks through inundation and provide some temperature benefits for outmigrating chinook salmon smolts. The rate of change for the descending limbs of the snowmelt hydrographs mimics natural receding snowmelt hydrograph rates.

Because of the long outmigration period for the three salmonid species combined, a variety of outmigrant temperature conditions are necessary throughout the spring/summer hydrographs. Recommended releases for Extremely Wet, Wet, and Normal water years provide optimal salmonid smolt temperatures (Table ES4). Marginal smolt temperatures will be provided throughout much of the outmigration period during Dry and Critically Dry water years. The lower releases during these year classes will allow mainstem water temperatures to warm earlier in the outmigration period, which will cue salmonids to outmigrate (warming temperatures are an important physiological signal to begin smoltification and outmigration) before water temperatures in the lower watershed are likely to become too warm to insure smolt survival. Following smolt temperature control releases, 450 cfs releases will be maintained to provide suitable temperature regimes for holding and spawning adult spring-run and fall-run chinook (Table ES5).

Channel Rehabilitation

Channel-rehabilitation activities are recommended along the mainstem Trinity River from Lewiston Dam to the North Fork Trinity River confluence. The intent of channel rehabilitation is to selectively remove the fossilized riparian berms (berms that have been anchored by extensive woody vegetation root systems and consolidated sand deposits) and recreate alternate bars. Channel rehabilitation is not intended to completely remove all riparian vegetation, but to remove vegetation at strategic locations to promote alluvial processes necessary for the restoration and maintenance of salmonid populations. The tightly bound berm material is hard to mobilize even at high flows, and mechanical berm removal is necessary. After selected berm removal, subsequent high-flow releases and coarse sediment supplementation will maintain these alternate bars and create a new dynamic channel. Specific channel rehabilitation recommendations vary by river segment between Lewiston Dam to the confluence of the North Fork Trinity River because the needs of channel rehabilitation change with tributary inputs of flow and sediment.

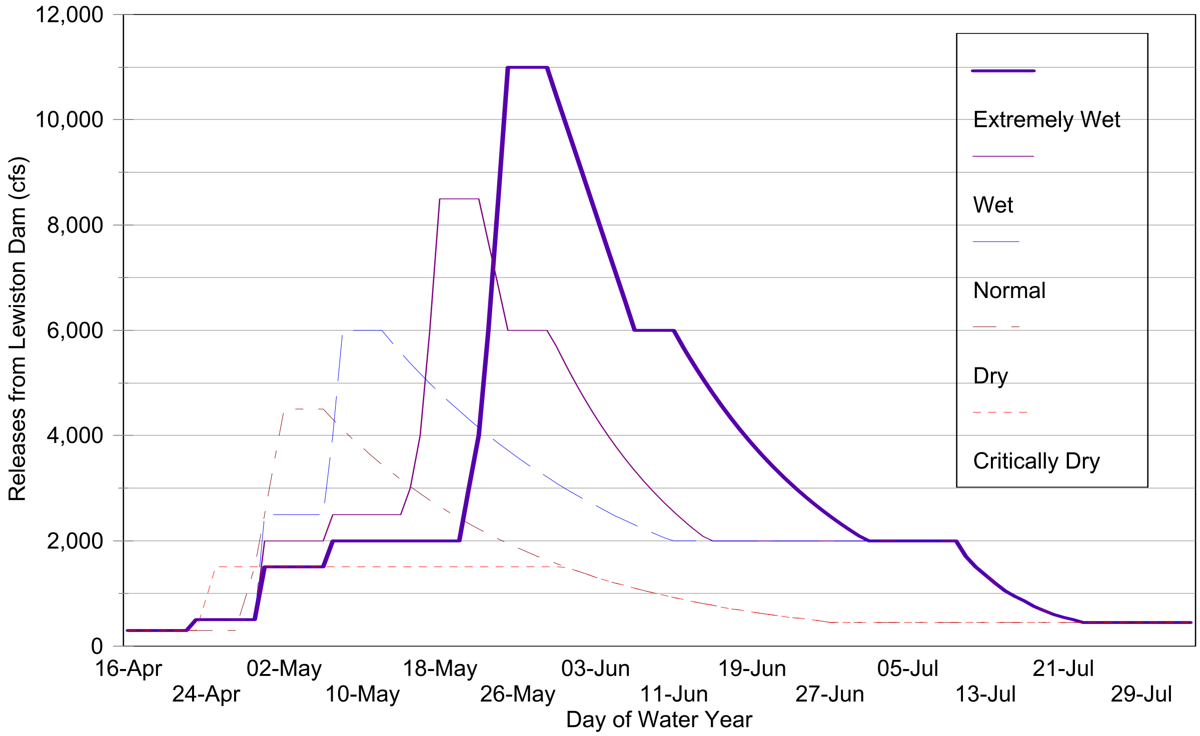

Figure ES1. Trinity River Flow Evaluation annual recommended hydrographs for each water year class: Extremely Wet, Wet, Normal, Dry, and Critically Dry. For all hydrographs, the recommended release from Lewiston Dam is 300 cfs from October 16 to April 8 and 450 cfs from August 1 to October 14.

The Service and Hoopa Valley Tribe identified 44 potential channel-rehabilitation sites, 3 potential side channel-rehabilitation sites, and 2 tributary delta maintenance sites. These sites are located where channel morphology, sediment supply, and high-flow hydraulics would encourage a dynamic, alluvial channel. A short implementation period for a significant number of these projects is recommended to evaluate whether they achieve their intended benefits: increasing the quality and quantity of salmonid habitat. Therefore, construction of 24 of the 44 channel-rehabilitation sites in the first 3 years of implementation is recommended. The remaining projects may proceed following evaluation by the AEAM program (see section on the AEAM program below).

Sediment Management

Sediment-management recommendations include: (1) immediate placement of more than 16,000 cubic yards of properly graded coarse sediment ($^{5}/_{16}$ to 5 inches) between Lewiston Dam and Rush Creek to restore the spawning gravel deficit caused by the elimination of upstream coarse sediment supply by the TRD; (2) annual supplementation of coarse sediment to balance the coarse sediment supply along the Lewiston Dam to Rush Creek segment; (3) reduction of fine sediment (< $^{5}/_{16}$ inch) storage in the mainstem by recommended flow releases; (4) prevention of fine sediment input from tributaries by mechanical removal from sedimentation ponds; and (5) reduction of fine sediment storage in the mainstem by mechanical removal. Channel-rehabilitation efforts also will remove large quantities (potentially up to 1 million cubic yards) of fine sediment stored in the riparian berms between Lewiston Dam and the North Fork Trinity River confluence.

Table ES3. Flow related geomorphic peak releases and durations with associated water-year classes and management objectives.

Peak Release (cfs)	Duration (days)	Water-Year Class	Management Objectives Achieved Through Flow Related Geomorphic Processes
1,500	36	Crit. Dry	• Prevention of germination/establishment of riparian vegetation low on alternate bars
4,500	5	Dry	• Mobilization of spawning gravels • Sand transport • All effects realized at lower flow level
6,000	5	Normal	• Channelbed surface mobilization • Significant mobilization of spawning gravels • Fine sediment movement • Channel migration • Floodplain inundation • Scour of 1-2 year old seedlings • Groundwater recharge of floodplain • All effects realized at lower flow levels
8,500	5	Wet	• Surface mobilization of alternate bars • Scour of bar margins • Coarse sediment movement • Scour of 2-3 year old seedlings • All effects realized at lower flow levels
11,000	5	Ext. Wet	• Significant scour of alternate bars • Large coarse sediment movement • Floodplain scour • Side-channel formation/maintenance • Sapling removal from alternate bars • All effects realized at lower flow levels

Table ES4. Water temperature objectives for the Trinity River salmonid smolts at the confluence of the Klamath and Trinity rivers for Extremely Wet, Wet, and Normal water year classes. These objectives are not met in Dry and Critically Dry water year classes because of the need to better synchronize Trinity River temperatures with those lower in the system.

Species	Temperature	Target Date
Steelhead	< 55.4ºF	May 22
Coho Salmon	< 59ºF	June 4
Chinook Salmon	< 62.6ºF	July 9

Table ES5. Water temperature objectives for the Trinity River during the summer, fall, and winter. Objectives are for the protection of holding and spawning salmon and steelhead.

	Temperature Objective Control Point	
Date	Douglas City (RM 92.2)	North Fork Trinity River (RM 72.4)
July 1 - September 14	60ºF	-
September 15 - September 30	56ºF	-
October 1 - December 31	-	56ºF

Adaptive Environmental Assessment and Management Program

The Trinity River Flow Evaluation Report, and the recommendations contained herein, are based on the best available scientific information compiled by a diverse group of scientists and engineers from various Federal, Tribal, and State agencies, and have been peer reviewed by outside experts and affected interests. Alluvial river systems are complex and dynamic. While our understanding of these systems and our predictive capabilities are extensive, some uncertainty over how the river and the fishery resources will react to the proposed recommendations still exists. Nonetheless, resource managers must make decisions and implement plans despite these uncertainties. AEAM provides a structured mechanism for fine-tuning management recommendations in relation to the recommended flows, sediment management, and channel rehabilitation activities.

Establishing an AEAM process for the Trinity River is recommended to guide future restoration activities. The proposed AEAM is an iterative 10-step process:

(1) Refine ecosystem goals and objectives;

(2) Monitor and assess the ecosystem baseline;

(3) Hypothesize biological/physical system behavior/response;

(4) Select future management actions;

(5) Implement management actions;

(6) Monitor the ecosystem response;

(7) Compare predictions with ecosystem response;

(8) Restate the ecosystem status;

(9) Use the adaptive process to evolve understanding of the ecosystem; and

(10) Assess continuing, modifying, or taking new actions.

Use of AEAM will assure restoration and maintenance of the fishery resources of the Trinity River and wise use of available water.

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CHAPTER 1 Introduction

1.1 Mandate

In 1955, Congress passed legislation (Public Law (P.L.) 84-386) (1955 Act) authorizing the construction of the Trinity River Division (TRD) of the Central Valley Project (CVP) to divert surplus water from the Trinity River into the Sacramento River. The 1955 Act also specifically authorized and directed the Secretary of the Interior (Secretary) to " . . . adopt appropriate measures to insure the preservation and propagation of fish and wildlife . . . " The U.S. House of Representatives report on the 1955 Act (USHOR, 1955) states:

. . . there is available for importation from the Trinity River, water that is surplus to the present and future needs of the Trinity and Klamath River Basins, and that surplus water, in the amount proposed in the Trinity division plan (704,000 acre-feet), can be diverted to the Central Valley without detrimental effect to the fishery resources.

For the 10 years after the TRD became operational in 1964, an average of 88 percent (1,234 thousand acre-feet (TAF)) of the annual inflow was diverted into the Sacramento River Basin, with releases to the Trinity River ranging from 150 to 250 cubic feet per second (cfs) and a total annual instream volume of 120.5 TAF (TRBFWTF, 1977). These minimum releases were thought, at that time, to be adequate to sustain the fishery resources of the Trinity River. The releases identified as appropriate to protect the fishery resources below the TRD addressed primarily chinook spawning needs (Moffett and Smith, 1950). These minimum releases, however, did not address the fluvial geomorphic processes that maintain habitat, nor did these minimum releases provide habitat for other species or other life stages of salmonids. Following construction and

> The 1955 Act authorized the TRD and directed the Secretary of the Interior to " . . . adopt appropriate measures to insure the preservation and propagation of fish and wildlife . . . " of the Trinity River.

operation of the TRD, rapid and unexpected changes in the river morphology caused the degradation of fish and wildlife habitat.

> Following construction and operation of the TRD, rapid and unexpected changes in the river morphology caused the degradation of fish and wildlife habitat, and salmonid populations noticeably decreased.

Within a decade of completion of the TRD, salmonid populations had noticeably decreased (Hubbel, 1973). Increased flow releases and habitat rehabilitation projects were identified as necessary to restore the fishery resources (TRBFWTF, 1977). On January 14, 1981, Secretary Cecil Andrus issued a Secretarial Decision and supporting documents (1981 Secretarial Decision, Appendix A) that directed the U.S. Fish and Wildlife Service (Service) to conduct the Trinity River Flow Evaluation (TRFE) Study. The mandate of this study was to determine how to restore anadromous fish populations in the Trinity River Basin.

The 1981 Secretarial Decision directed the Service to submit a report summarizing the effects of minimum releases and other actions in restoring Trinity River salmon and steelhead populations. The report was to address habitat availability over a range of instream water volumes (140 TAF to 340 TAF), and the need to maintain, increase, or decrease these volumes. The report was also to recommend specifically what actions should be continued, eliminated, or implemented to mitigate fish population declines attributable to the TRD.

> The 1981 Secretarial Decision directed the U.S. Fish and Wildlife Service to conduct the Trinity River Flow Evaluation Study to determine how to restore fish populations in the Trinity River Basin, and to recommend specifically what actions should be continued, eliminated, or implemented to mitigate fish population declines attributable to the TRD.

1.2 Purpose of the Trinity River Flow Evaluation Report

This report provides recommendations to the Secretary of the Interior designed to fulfill fish and wildlife protection mandates of the 1955 Act, the 1981 Secretarial Decision, 1984 Trinity River Basin Fish and Wildlife Management Act, 1991 Secretarial Decision, the 1992 Central Valley Project Improvement Act, and the federal trust responsibility to restore and maintain the Trinity River fishery resources.

This report:

- describes Congressional, Secretarial, and other actions taken to address the declines of the Trinity River fishery resources;
- presents the current scientific knowledge of the Trinity River, including changes in channel morphology and overall quality of fish habitat; and
- concludes that a new channel configuration, with accompanying adaptive management of releases, will provide water temperature control and sediment transport needed to create the dynamic habitat required to restore and maintain the fishery resources of the Trinity River Basin.

The science at the time of the 1981 Secretarial Decision focused on single species management. In response to an increasing awareness and understanding of river ecosystems and fishery habitats, additional studies that addressed channel morphology, sediment, water temperature, and

other ecosystem processes were initiated. This report makes management recommendations based on information provided in the following studies:

- Salmonid Microhabitat
- Channel Rehabilitation Microhabitat
- Fine Sediment Transport and Spawning Gravel Flushing
- Investigations of the Alluvial River Attributes
- Flow-Water Temperature Relations
- Chinook Salmon Potential Production

> "This report provides recommendations to the Secretary of the Interior designed to fulfill fish and wildlife protection mandates . . . "

Integrating the results of these studies provides the scientific basis necessary to satisfy Secretarial and Congressional mandates. Fundamentally, this report acknowledges that native fish and wildlife species evolved and adapted to the fluvial processes and habitats characteristic of the pre-disturbance Trinity River, and restoring salmonid populations must be founded on rehabilitating and managing fluvial processes that create and maintain habitats vital to anadromous fish.

Subsequent chapters are summarized below:

Chapter 2: Background: Water Management and Fishery Restoration Activities chronicles events leading up to the 1981 Secretarial Decision and subsequent legislative and administrative actions addressing restoration efforts in the Trinity River Basin. The Trinity River Division of the Central Valley Project facilities also are described.

Chapter 3: Fish and Wildlife Background presents detailed descriptions of the life histories and habitat requirements of Trinity River anadromous salmonids, as well as other fish and semi-aquatic species that live in the Trinity River.

Chapter 4: A Historical Perspective to Guide Future Restoration describes the general physical, hydrological, and biological setting of the Trinity River prior to and after construction of the TRD— specifically, the hydrology, fluvial geomorphology, and riparian communities of the Trinity River. Specific alluvial river attributes that link natural riverine processes necessary to rehabilitate salmonid habitat are presented.

Chapter 5: Study Approaches and Results describes individual studies, conducted as a part of the Flow Evaluation, and other studies, conducted under the Trinity River Restoration Program, that addressed restoration and maintenance of the habitat necessary to the fishery resources of the Trinity River.

Chapter 6: Evaluation of the 1981 Secretarial Decision Volumes evaluates annual instream volumes of 140, 220, 287, and 340 TAF, as identified in the 1981 Decision.

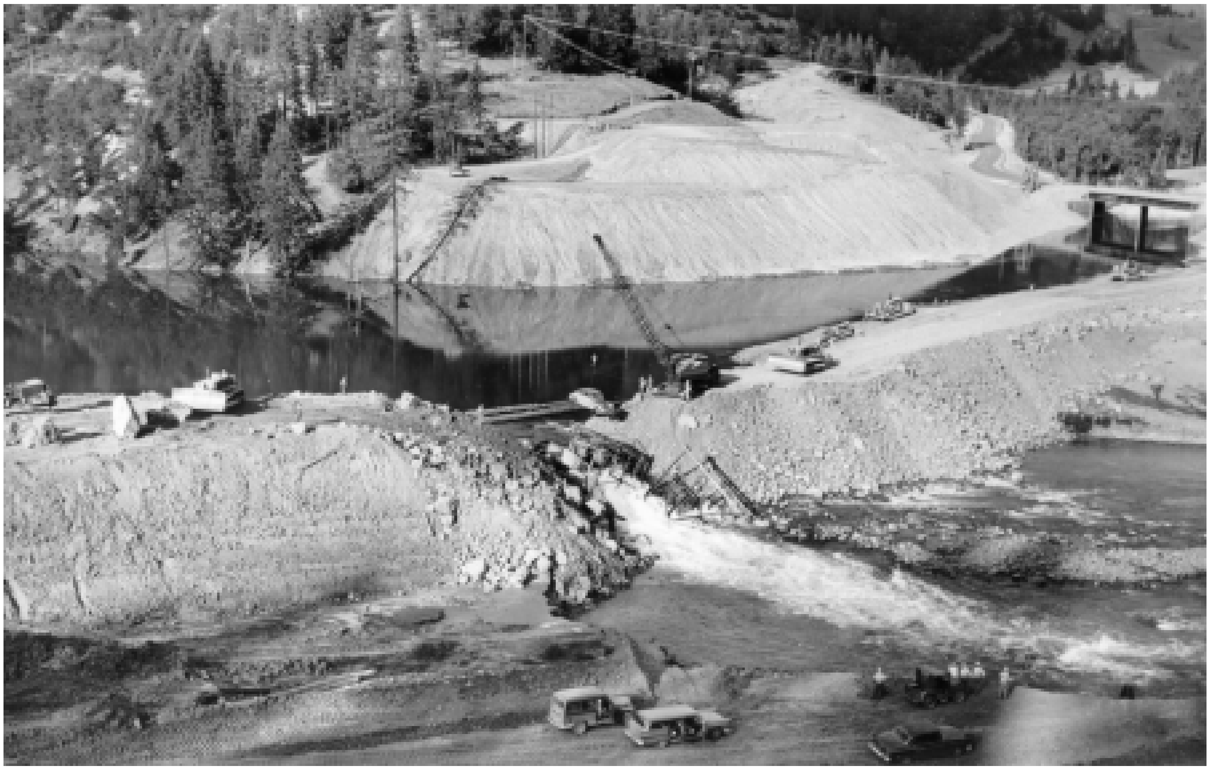
Chapter 7: Restoration Strategy presents the overall strategy necessary to rehabilitate the mainstem Trinity River and restore its fishery resources.

Chapter 8: Recommendations presents recommended flow regimes, sediment, and channel rehabilitation actions necessary to restore and maintain the Trinity River fishery resources. Management objectives and recommendations to achieve these objectives are

> "The science at the time of the 1981 Secretarial Decision focused on single species management. In response to an increasing awareness and understanding of river ecosystems and fishery habitats, additional studies that addressed channel morphology, sediment, water temperature, and other ecosystem processes were initiated."

> Restoring salmonid populations must be founded on rehabilitating and managing fluvial processes that create and maintain habitats vital to anadromous fish.

presented. Also included is a recommendation to establish an Adaptive Environmental Assessment and Management program to guide future restoration activities and modify management recommendations.



CHAPTER 2 Background: Water Management and Fishery Restoration Actions

2.1 Authorization, Construction, and Facilities of the Trinity River Division

The Trinity River, located in northwest California, is the largest tributary to the Klamath River (Figure 2.1). Water export and energy generation from the Trinity River were envisioned as early as 1931, when plans for diverting Trinity River water to the Sacramento River were included as part of the California State Water Plan (TRBFWTF, 1977). Plans involving the Trinity River Division were removed from the California State Water Plan in 1945 (USBOR, 1952), but these plans were subsequently adopted and refined by the U.S. Bureau of Reclamation (Reclamation) and the U.S. Army Corps of Engineers.

In 1949, Reclamation released preliminary plans to develop the Trinity River as part of the CVP. In 1953, the Secretary transmitted to Congress the reports and findings of the Department's agencies regarding the proposed plan.

The TRD was authorized by an act of Congress on August 12, 1955, (P.L. 84-386). Section 1 of the 1955 Act provided for the construction, operation, and maintenance of the TRD. Section 2, however, specifically authorized and directed the Secretary to " . . . adopt appropriate measures to insure the preservation and propagation of fish and wildlife[.]" Congress stated that an average annual supply of 704 TAF of water, considered surplus to the present and future needs of the Trinity River Basin, could be exported from the Trinity River Basin to the Central Valley " . . . without detrimental effect on the fishery resources . . . " (H.R. Rep. No. 602, 84th Cong., 1st Sess. 4-5 (1955); S. Rep. No. 1154, 84th Cong., 1st Sess. 5 (1955)). Reclamation completed the Trinity River Division in 1964.

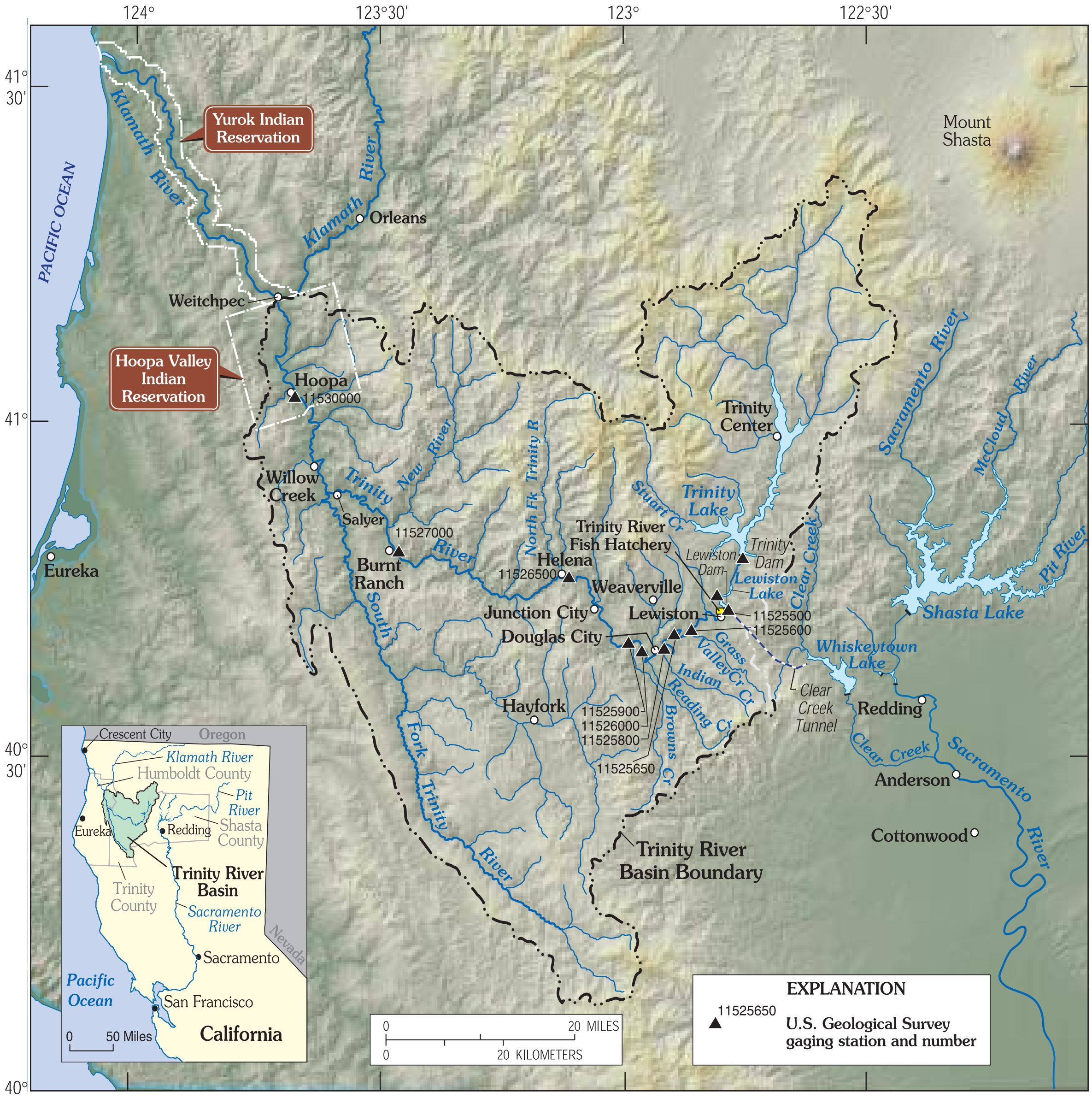


Figure 2.1. The Trinity River Basin and adjacent area in northwestern California.

The Shasta (authorized in 1935 and completed in 1945) and Trinity River Divisions of the Central Valley Project store and transfer water resources of the Trinity and northern Sacramento River basins to the Central Valley (Figure 2.2). Water from the Trinity River Basin is stored, regulated, and diverted through a system of dams, reservoirs, tunnels, and powerplants. The system diverts the water south into Clear Creek, the Sacramento River, and the Central Valley of California. A brief description of pertinent facilities is presented below.

Trinity Dam and Lake: Trinity Dam regulates flows and stores water for various uses. Completed in 1962, Trinity Dam is an earthfill structure 538 feet high with a crest length of 2,450 feet. The dam forms Trinity Lake, which

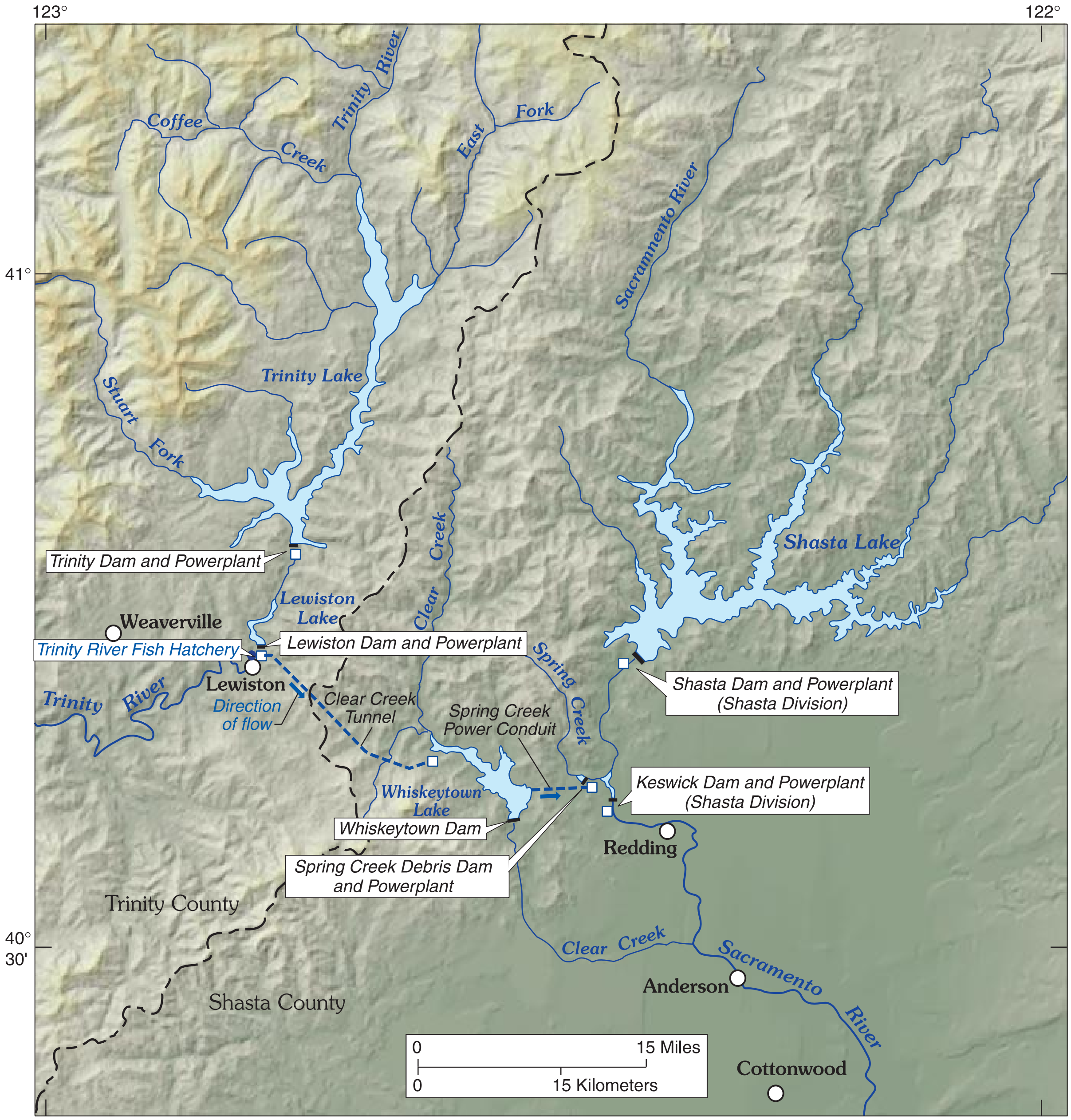


Figure 2.2. Trinity River and Shasta Division of the Central Valley Project.

has a storage capacity of 2,448,000 acre-feet. The lake offers recreation facilities for camping, boating, water skiing, swimming, fishing, and hunting.

Trinity Powerplant: Trinity Powerplant at Trinity Dam has two generators with a total capacity of 105,556 kilowatts (Figure 2.2).

Lewiston Dam and Lake: Lewiston Dam is about 8 miles downstream from Trinity Dam. The dam creates an afterbay to Trinity Powerplant and regulates releases into the Trinity River. Lewiston Dam is an earthfill structure 91 feet high and 754 feet long, forming a reservoir with a storage capacity of 14,660 acre-feet. The trans-basin diversion begins at Lewiston Lake via Clear Creek Tunnel to Whiskeytown Lake.

Lewiston Powerplant: Lewiston Powerplant at Lewiston Dam has one generator with a capacity of 350 kilowatts (Figure 2.2).

Trinity River Fish Hatchery: The Trinity River Fish Hatchery (TRFH), operated by the California Department of Fish and Game (CDFG), has a production capacity of roughly 40 million salmonid eggs. It is located immediately downstream from Lewiston Dam. The hatchery was constructed and operated to help mitigate for lost production from habitats upstream from the TRD.

Clear Creek Tunnel: Clear Creek Tunnel, 17.5 feet in diameter and 10.7 miles long, conveys up to 3,200 cfs from Lewiston Lake to Judge Francis Carr Powerhouse and Whiskeytown Lake. It is the conduit for the trans-basin diversion.

Judge Francis Carr Powerhouse: Judge Francis Carr Powerhouse, on Clear Creek, has two generators with a total capacity of 141,444 kilowatts.

Whiskeytown Dam and Lake: Located on Clear Creek, Whiskeytown Dam stores Clear Creek runoff and diverted Trinity River flows discharged from Judge Francis Carr Powerhouse. The dam is an earthfill structure 282 feet high with a crest length of 4,000 feet. Whiskeytown Lake has a capacity of 241,100 acre-feet and provides recreation facilities for picnicking, camping, swimming, boating, water skiing, fishing, and hunting. The Spring Creek Tunnel diverts water from Whiskeytown Lake to the Spring Creek Powerhouse and Keswick Dam on the Sacramento River.

2.2 Early Operation of TRD

Over the first 10 years of full TRD operations, water years (WY) 1964-1973, 88 percent of the inflow of the Trinity River (averaging annually 1,234 of 1,396 TAF) into Trinity Lake (formerly Clair Engle Reservoir) was diverted into the Sacramento River Basin. Until 1974, Reclamation operated the TRD to release a minimum flow into the Trinity River ranging from 150 to 250 cfs for fishery resource purposes, pursuant to provisions of the 1955 Act. Studies supporting the 1955 Act determined that an annual instream fishery volume of 120.5 TAF was necessary to maintain or improve the fish and wildlife resources (TRBFWTF, 1977). The original release schedule and annual instream volume focused primarily on providing fish habitat for spawning chinook (Moffett and Smith, 1950). Within a decade of the completion of the TRD, salmonid populations had noticeably decreased (Hubbel, 1973).

"Over the first 10 years of full TRD operations, water years (WY) 1964-1973, 88 percent of the inflow of the Trinity River (averaging annually 1,234 of 1,396 TAF) into Trinity Lake was diverted into the Sacramento River Basin."

2.3 Trinity River Basin Fish and Wildlife Task Force

The decline of the salmon and steelhead populations led to the formation in 1971 of the Trinity River Basin Fish and Wildlife Task Force (TRBFWTF). Members included Federal, State, Tribal, and local agencies. This Task Force developed the Trinity River Basin Comprehensive Action Program (TRBFWTF, 1977) to halt the degradation of fish and wildlife habitat in the Basin and formulate a long-term management program for the Trinity River.

2.4 Increased Flow Regimes in the 1970's

In 1973, the California Department of Fish and Game (CDFG) requested that Reclamation release an annual volume of 315 TAF into the Trinity River to " . . . reverse the steelhead and fall-run king [chinook] salmon declines." (TRBFWTF, 1977). In 1974, CDFG began a 3-year experiment to determine the effects of this increased streamflow on salmon and steelhead populations, but a combination of flood and drought

conditions resulted in the annual instream flows totaling 705 TAF in 1974, 275 TAF in 1975, and 126 TAF in 1976. Since the 3-year experiment could not be completed as designed, no formal evaluation of the flows was made.

In 1978, the Service conducted a microhabitat study investigating the relation between streamflows and anadromous fish habitats in the Trinity River (USFWS, 1980a). The study concluded that substantial gains in fish habitat for specific life stages would be achieved if the annual instream flow regime were raised to 287 TAF. Ultimately, the study concluded that an instream flow regime of 340 TAF would be necessary after a stream restoration program was implemented. The report noted that, in some cases, habitat gains for some life stages would occur at the expense of habitat reduction for other life stages.

> " . . . the [1980] EIS concluded that insufficient streamflow was the most critical limiting factor, and that increased flows would result in immediate improvement in fish habitat and fish runs . . . "

An Environmental Impact Statement (EIS), prepared in 1980, addressed the Department of the Interior's proposal to restore salmon and steelhead populations by increasing streamflows in the Trinity River (USFWS, 1980b). The EIS determined that an 80 percent decline in chinook salmon and a 60 percent decline in steelhead populations had occurred since the commencement of TRD operations. The EIS further estimated the total salmonid habitat loss in the Trinity River Basin to be 80 to 90 percent. The EIS concluded that the fundamental factors causing the decline in fishery resources were insufficient streamflow, streambed sedimentation, and inadequate regulation of fish harvest. While recognizing that full restoration of the fisheries must address each of those factors, the EIS concluded that insufficient streamflow was the most critical limiting factor, and that increased flows would result in immediate improvement in fish habitat and fish runs; thus, an increase in flows was deemed a necessary first step in restoring Trinity River fishery resources.

2.5 Secretarial Decision of 1981

Supported by the 1980 EIS, Secretary Cecil Andrus issued a Secretarial Decision on January 14, 1981, that directed the Service to conduct the Trinity River Flow Evaluation to evaluate the effects on fish habitat by increasing annual instream releases to 140 TAF in critically dry water years, 220 TAF in dry water years, and 340 TAF in normal or wetter water years, and to recommend long-term flow releases. On the same date, the Secretary affirmed an agreement (Appendix B) between the Service and Reclamation (then the Water and Power Resources Service) concerning the flow evaluation. The agreement stated that the Trinity River Flow Evaluation Report would: (1) summarize the effectiveness of flow restoration and other measures, including intensive stream and watershed management programs, in rebuilding Trinity River salmon and steelhead stocks; (2) address the adequacy of habitat at specific instream releases discussed above and the need to maintain, increase, or decrease the 340 TAF flow regime; (3) recommend measures to mitigate fishery habitat impacts attributable to the TRD; and (4) recommend appropriate flows and other measures necessary to better maintain favorable instream habitat conditions.

2.6 Congressional Responses in the 1980's to Declining Fish and Wildlife Resources

One of the first congressional responses to the decline of the Trinity River fishery resources was the enactment of the Trinity River Stream Rectification Act in 1980 (P. L. 96-335) to control sand deposition from the degraded watershed of Grass Valley Creek, a tributary to the Trinity River (Figure 2.1). However, by 1984, Congress had concluded that the reduction in streamflows below Lewiston Dam was a principal cause of the drastic reduction in fish populations.

In 1984, Congress passed the Trinity River Basin Fish and Wildlife Management Act, P. L. 98-541 (1984 Management Act). In this Act, Congress found that the TRD's operations substantially reduced instream flows in the Trinity River, resulting in degraded fish habitat (pools, spawning gravels, and rearing areas) and consequently a drastic reduction in anadromous fish populations. Congress further found that construction of the TRD reservoirs contributed to reductions in the terrestrial wildlife populations historically found in the Basin because habitat was inundated by the reservoirs. Congress also found that factors not related to the TRD, including watershed erosion and fishery harvest management practices, had significantly reduced the Basin's fish and wildlife populations. A similar Act, the Klamath River Basin Conservation Restoration Area Act 16 U.S.C § 460ss et seq.9(P.L. 99-552), was passed in 1986 for the entire Klamath River Basin. This companion Act provided additional authority to the Secretary "... to implement a restoration program in cooperation with State and local governments to restore anadromous fish populations to optimum levels in both the Klamath and Trinity River Basins." Id. § 460ss(9).

The 1984 Management Act directed the Secretary to develop a management program to restore fish and wildlife populations in the Basin to levels approximating those that existed immediately before TRD construction began. The Act statutorily established the Trinity River Fish and Wildlife Task Force as an advisory committee to the Secretary. The Act directed the Secretary to use the fish and wildlife management program prepared in 1983 by the prior-existing Task Force to develop a fish and wildlife restoration program (Program). The Act further directed that the Program include efforts aimed toward the rehabilitation of fish habitat in the Trinity River and its tributaries, modernization and increased effectiveness of the TRFH, monitoring of fish and wildlife populations and the effectiveness of rehabilitation work, advising the Pacific Fisheries Management Council (PFMC) on salmon harvest management plans, and "other activities as the Secretary determines to be necessary to achieve the long-term goal of the program."

Congress reauthorized the 1984 Act in 1996 (P.L. 104-143) and, among other things, amended its goal to clarify that the management program is intended to aid in the resumption of fishing activities (recreational, non-tribal commercial, and Tribal) and that restoration will be measured not only by returning salmon and steelhead spawners but also by the ability of dependent Tribal and non-tribal fishers to participate fully in the benefits of restoration through enhanced harvest opportunities. Additionally, the 1984 Management Act was amended to clarify that the TRFH should not impair efforts to restore and maintain naturally reproducing anadromous fish stocks within the Basin.

A major component of the Program has been a watershed rehabilitation program to reduce fine sediment input, primarily decomposed granite, from tributaries of the upper Trinity River below Lewiston Dam (TCRCD and NRCS, 1998). Construction of Buckhorn Debris Dam on Grass Valley Creek in 1990, pursuant to P. L. 96-335, and the purchase and rehabilitation of portions of the Grass Valley Creek watershed in 1993, have assisted in

> "... Congress found that the TRD's operations substantially reduced instream flows in the Trinity River, resulting in degraded fish habitat (pools, spawning gravels, and rearing areas) and consequently a drastic reduction in anadromous fish populations .... The 1984 Management Act directed the Secretary to develop a management program to restore fish and wildlife populations in the Basin to levels approximating those that existed immediately before TRD construction began."

the reduction of sand input into the mainstem Trinity River. The Bureau of Land Management (BLM) and the United States Forest Service (USFS) also have undertaken substantial watershed rehabilitation activities to reduce erosion (BLM, 1995).

> "Since the implementation of the Program, more restrictive management of commercial, sport, and Tribal fisheries has greatly reduced the harvest impacts on fall chinook from the Klamath Basin (which includes Trinity stock) from the levels that occurred in the late 1970's and early 1980's."

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The Program has provided estimates of the annual run sizes of salmonids (spring and fall chinook salmon, coho salmon, and steelhead) in the Trinity River. This information has been used to manage the Klamath Basin fisheries. Since the implementation of the Program, more restrictive management of commercial, sport, and Tribal fisheries has greatly reduced the harvest impacts on fall chinook from the Klamath Basin (which includes Trinity stock) from the levels that occurred in the late 1970's and early 1980's (KRTAT, 1986; PFMC, 1988). These reductions also would have reduced harvest impacts on Trinity River spring chinook salmon stocks. The impacts that ocean fisheries have on Trinity River coho have been greatly reduced since 1994, when ocean fishery management was modified to protect Oregon coastal coho salmon stocks (PFMC, 1995).

2.7 Increased Flow Regimes in the 1990's

Four of the first six years of the Trinity River Flow Evaluation Study were designated as dry water years under criteria established in the 1981 Secretarial Decision, due to drought conditions in California from 1986 through 1990. As a result, the Hoopa Valley Tribe filed an administrative appeal seeking Secretarial intervention to resolve issues pertaining to dry-year flow reductions. In July 1990, the Secretary directed the Service to review Trinity River flows as originally described by the 1981 Secretarial Decision. In January 1991, the Service developed an environmental assessment (EA) tiered to the 1980 EIS that analyzed the environmental impacts of a proposal to provide " . . . at least 340 TAF for each dry or wetter water year and 340 TAF in each critically dry year, if at all possible." This 1991 EA was adopted by the Secretary, and a Finding of No Significant Impact (FONSI) was made (Secretarial Decision on Trinity River Flows, 1991; Appendix C).

2.8 Central Valley Project Improvement Act

In 1992, Congress enacted the Central Valley Project Improvement Act, Title XXXIV of P.L. 102-575 (CVPIA). Among other purposes described in section 3402 of the CVPIA, Congress intended the statute " . . . to protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River Basins . . . " and " . . . to address impacts of the Central Valley Project on fish, wildlife, and associated habitats." The CVPIA includes several provisions related to the TRD such as Section 3406(b)(19) addressing carry-over storage and Section 3406(e)(4) addressing studies evaluating the need for temperature control devices at Trinity Dam and Reservoir. In order to meet the Federal Government's trust responsibility to protect the fishery resources of the Hoopa Valley Tribe, as well as to meet the fishery restoration goals of the 1984 Act, section 3406(b)(23) of the CVPIA directed the Secretary to provide annual instream flow releases into the Trinity River of not less than 340 TAF for the purposes of fishery restoration, propagation, and maintenance pending the completion of the study directed by Secretary Andrus. This section further required that the Trinity River Flow Evaluation Study be completed " . . . in a manner which insures the development of recommendations, based on the best available scientific data, regarding permanent instream fishery flow requirements and Trinity River Division operating criteria and procedures for the restoration and maintenance of the Trinity River fishery."

"In order to meet the Federal Government's trust responsibility to protect the fishery resources of the Hoopa Valley Tribe, as well as to meet the fishery restoration goals of the 1984 Act, section 3406(b)(23) of the CVPIA directed the Secretary to provide annual instream flow releases into the Trinity River of not less than 340 TAF for the purposes of fishery restoration, propagation, and maintenance. . . ."

If both the Secretary and the Hoopa Valley Tribe concur in the recommendations, the Secretary shall implement them accordingly. If the Hoopa Valley Tribe and the Secretary do not concur, then the minimum releases of 340 TAF shall continue unless increased by Congress, by judicial decree, or by an agreement between the Secretary and the Hoopa Valley Tribe.

2.9 Tribal Trust Responsibility

The 1981 Secretarial Decision directed the Trinity River Flow Evaluation Study based on the conclusion that the Secretary's statutory responsibilities, as well as the Federal trust responsibility to the Hoopa Valley and Yurok tribes, " . . . compel restoration of the river's salmon and steelhead resources to pre-project levels." In 1993, the Department of the Interior's Solicitor elaborated on the Federal Government's trust responsibility to the Hoopa Valley and Yurok Tribes (DOI, 1993). The Solicitor stated that the Hoopa Valley and Yurok Tribes' reserved fishing rights include the right to harvest quantities of fish on their reservations sufficient to support a moderate standard of living, and that the Tribes' reserved fishing rights include the right to fish for ceremonial, subsistence, and commercial purposes. Because of the depressed condition of the fishery, the Tribes are entitled, under the Solicitor's Opinion, to 50 percent of the harvest. The Ninth Circuit Court of Appeals concluded that the Federal Government's trust responsibility includes the duty to preserve the Hoopa Valley and Yurok Tribes' fishing rights (Parravano v. Babbitt, 70 F.3d 539, 546-47 (9th Cir. 1995) cert. denied, 116 S.Ct. 2546 (1996)). One of the expected results of the restoration measures recommended in this Trinity River Flow Evaluation Report, including instream flows from the TRD, is to meet the Secretary's trust responsibility to restore and maintain the Tribal fisheries.

"...the Hoopa Valley and Yurok Tribes' reserved fishing rights include the right to harvest quantities of fish on their reservations sufficient to support a moderate standard of living, and that the Tribes' reserved fishing rights include the right to fish for ceremonial, subsistence, and commercial purposes."

CHAPTER 8 Recommendations

Integration of information collected during studies performed as part of the TRFE and contemporary scientific knowledge of alluvial river channels and riverine ecology have guided the recommendations for restoring and maintaining the fishery resources of the Trinity River. Rehabilitation of the mainstem Trinity River and restoration and maintenance of its fishery resources requires (1) increased annual instream volumes and variable reservoir release schedules, (2) fine and coarse sediment management, and (3) mainstem channel rehabilitation. These actions and resulting recommendations are derived from the best available science. Our achievements will be evaluated over time to document success as well as to make necessary refinements based on our evolving scientific understanding of the consequences of our actions. These refinements will allow us to improve both the rate and efficiency by which we achieve our goals. The process employed to achieve these refinements is described in Section 8.4, Recommended Adaptive Environmental Assessment and Management Program.

> "Rehabilitation of the mainstem Trinity River and the restoration and maintenance of its fishery resources requires (1) increased annual instream allocations and variable reservoir release schedules, (2) fine and coarse sediment management, and (3) mainstem channel rehabilitation."

8.1 <u>Annual Instream Flow Regimes</u>

Recommended flow regimes and release schedules were developed on the basis of a water-year classification and the hydrograph components necessary to meet objectives for each water-year class. Individual hydrograph components were assembled into recommended annual

hydrographs on the basis of the targeted fluvial processes and habitat conditions, which often vary by water-year class.

Variability is a keystone to management strategy because no single annual flow regime can be expected to perform all functions needed to maintain an alluvial river system and restore the fishery resources. Inter-annual flow variability (Attribute No. 2, see Section 4.8) is achieved by recommending unique annual flow releases for each water-year class. Unregulated runoff into Trinity Lake will be used to designate the water-year class in each year (Table 8.1), in order that the various targeted fluvial processes will be met with appropriate frequencies. Annual flow regimes vary by water-year class, because they were derived on the basis of the total amount of water necessary to meet the management objectives for each water-year class.

> "...no single annual flow regime can be expected to perform all functions needed to maintain an alluvial river system and restore the fishery resources."

8.1.1 Management Objectives by Water-Year Class

Flow releases must satisfy desired fluvial processes and habitat conditions for each water-year class. The restoration strategy (Chapter 7) broadly describes these release objectives, but it does not assign each of these objectives to a water-year class. Targeted fluvial processes and desired habitat conditions (microhabitat and temperature objectives) were assigned to each water-year class (Tables 8.2 and 8.3). Some processes and habitat conditions, such as favorable spawning and rearing microhabitat, were assigned to all water-year classes. Others, such as floodplain inundation (Attribute No. 7, Section 4.8), were assigned only to the wetter water-year classes.

8.1.2 Hydrograph Components and Releases Necessary to Meet Management Objectives

The studies (Chapter 5) provided three sets of flow-related management objectives: (1) releases to provide suitable salmonid spawning and rearing microhabitat (Table 8.3); (2) snowmelt peak and recession hydrograph components to satisfy fluvial geomorphic and woody riparian objectives that are necessary for the creation and maintenance of diverse salmonid habitats (Table 8.2); and (3) releases to meet appropriate water-temperature objectives for holding/spawning chinook salmon and outmigrating salmonid smolts (Table 8.3). Releases from the TRD were specified that would achieve these management objectives.

8.1.2.1 <u>Rearing and Spawning Microhabitat Management Objectives</u>

On the basis of the analysis of habitat availability in the existing channel, and considering all anadromous salmonid life stages, a release of 150 cfs provides the greatest amount of microhabitat in the mainstem Trinity River from Lewiston Dam to Weitchpec (Chapter 5.1). As with any use of PHABSIM habitat modeling, the weighted usable area indices must be interpreted in the context of fish life-history patterns and habitat needs, streamflow patterns (both existing and historical), water temperature, and changing channel morphology, according to the procedures of the Instream Flow Incremental Methodology (Bovee, 1982). When considering fish life histories and water-temperature needs, specifically holding and spawning temperature preferences (Chapter 5.5), a 300-cfs release provides suitable microhabitat and macrohabitat for spawning and rearing chinook salmon, coho

> "....a 300-cfs release provides suitable microhabitat and macrohabitat for spawning and rearing chinook salmon, coho salmon, and steelhead in the Trinity River above the North Fork Trinity River in the current channel morphology."

Table 8.1. Trinity River water-year classifications and probability of each water-year class occurring.

Water-Year Class	Probability of Occurrence
Extremely Wet	0.12
Wet	0.28
Normal	0.20
Dry	0.28
Critically Dry	0.12

salmon, and steelhead in the Trinity River above the North Fork Trinity River in the current channel morphology (Segment I, Figure 5.1). Recommended releases focus on this segment because it is most affected by releases from Lewiston Dam. Maintaining 300 cfs as the winter baseflow provides spawning habitat throughout the chinook salmon, coho salmon, and steelhead spawning seasons and protects early life stages throughout incubation and emergence periods for all salmonid species (Figure 3.1). Recommendations based on current rearing and spawning microhabitat data will have to be re-evaluated through an adaptive management process (Section 8.4) after channel morphology changes (Section 8.3).

8.1.2.2 Fluvial Geomorphic Management Objectives

Fluvial geomorphic management objectives are based on the alluvial-attribute thresholds (Sections 5.3 and 5.4). The majority of these objectives can be met during the snowmelt peak and snowmelt recession hydrograph. The snowmelt peak and recession hydrograph components historically varied and therefore recommendations also vary for each water-year class (Figure 8.1; Sections 5.3 and 5.4). Recommended snowmelt peak magnitudes were based on threshold shear stresses estimated as necessary for achieving Attribute Nos. 3 and No. 4. Critically Dry years were not expected to achieve either attribute. The 5-day peak release during all water years except Critically Dry provides sufficient duration to transport coarse bed material originating from tributaries in most years (refer to Attribute No. 5 of McBain and Trush (1997) for greater detail). Staggered timing of snowmelt peak runoff was based on historical timing by average water-year class (Figure 5.27).

Following the snowmelt peak, Extremely Wet and Wet snowmelt hydrographs have two distinct segments to their descending limbs (with distinct differences in rate of change in declining discharge) separated by a short duration "bench" at 6,000 cfs. Both segments (the latter designated the snowmelt recession hydrograph component) mimic the same rate of change as unimpaired snowmelt hydrographs (Figure 8.1, Appendix J). So that cottonwood seedling roots can better follow the declining groundwater table, flow recession rates mimic the unimpaired snowmelt hydrograph, which will likely promote the annual recruitment of cottonwoods (Rood and Mahoney, 1990; Segelquist et al., 1993; Merigliano, 1996). The 6,000-cfs "bench" promotes transport of fine bed material once peak flows have mobilized the surface layer of the channelbed and

> "The majority of these [fluvial geomorphic management] objectives can be met during the snowmelt peak and snowmelt recession hydrograph."

Table 8.2. Primary fluvial geomorphic management objectives for the Trinity River by water-year class (Attributes from Section 4.8).

Year Class	Management Objectives
Extremely Wet	• Mobilization of matrix particles (D_{84}) on alternate bar surfaces (Attribute 3) • Channelbed scour greater than 2 D_{84}'s depth and redeposition of gravels on face of alternate bars (Attribute 4) • Transport sand out of the reach at a volume greater than input from tributaries to reduce instream sand storage (Attribute 5) • Transport coarse bed material at a rate near equal to input from tributaries to route coarse sediment, create alluvial deposits, and eliminate tributary aggradation (Attribute 5) • Periodic channel migration (Attribute 6) • Floodplain creation, inundation, and scour (Attribute 7) • Channel avulsion (Attribute 8) • Woody riparian mortality on lower alternate bar surfaces and woody riparian regeneration on upper alternate bar surfaces and floodplains (Attribute 9) • Maintain variable water table for off-channel wetlands and side channels (Attribute 10)
Wet	• Mobilization of matrix particles (D_{84}) on alternate bar surfaces (Attribute 3) • Channelbed scour greater than 1 D_{84}'s depth and redeposition of gravels (Attribute 4) • Transport sand out of the reach at a volume greater than input from tributaries to reduce instream sand storage (Attribute 5) • Transport coarse bed material at a rate near equal to input from tributaries to route coarse sediment, create alluvial deposits, and eliminate tributary aggradation (Attribute 5) • Periodic channel migration (Attribute 6) • Floodplain creation, inundation and occasional scour (Attribute 7) • Woody riparian mortality on lower alternate bar surfaces and woody riparian regeneration on upper alternate bar surfaces and floodplains (Attribute 9) • Maintain fluctuating water table for off-channel wetlands and side channels (Attribute 10)
Normal	• Mobilization of matrix particles (D_{84}) on general channelbed surface and along flanks of alternate bar surfaces (Attribute 3) • Channelbed scour and redeposition of gravels (Attribute 4) • Transport sand out of the reach at a volume greater than input from tributaries to reduce instream sand storage (Attribute 5) • Transport coarse bed material at a rate near equal to input from tributaries to route coarse sediment, create alluvial deposits, and eliminate tributary aggradation (Attribute 5) • Frequent floodplain inundation (Attribute 7) • Woody riparian vegetation mortality along low water edge of alternate bar surfaces and woody riparian regeneration on upper alternate bar surfaces and floodplains (Attribute 9) • Maintain fluctuating water table for off-channel wetlands and side channels (Attribute 10)
Dry	• Channelbed surface mobilization of in-channel alluvial features (e.g., spawning gravel deposits) (Attribute 3) • Transport sand out of the reach at a volume greater than input from tributaries to reduce instream sand storage(Attribute 5) • Transport coarse bed material at a rate near equal to input from tributaries to route coarse sediment, create alluvial deposits, and eliminate tributary aggradation (Attribute 5) • Discourage germination of riparian plants on lower bar surfaces for a portion of the seed release period (Attribute 9) • Maintain variable water table for off-channel wetlands and side channels (Attribute 10)
Critically Dry	• Discourage germination of riparian plants on lower bar surfaces for the early portion of the seed release period (Attribute 9) • Minimally recharge groundwater (Attribute 10)

Table 8.3. Salmonid microhabitat and temperature objectives for the Trinity River by water-year class.

Water Year Class	Microhabitat Objectives	Temperature Objectives
Extremely Wet, Wet, and Normal	Provide the greatest amount of spawning and rearing microhabitat for anadromous salmonids in the existing channel, given the needs of the various life-stages.	Provide suitable temperatures for holding spring chinook and spawning spring and fall chinook by meeting temperature standards of: <60° F from July 1 to September 14 at Douglas City (RM 93.7), <56° F from September 15 to September 30 at Douglas City, and <56° F from October 1 to December 31 at the North Fork Trinity River confluence (RM 72.4). Provide optimal temperatures for anadromous salmonids throughout their outmigration by meeting temperature targets at Weitchpec (RM 0.0) of: <55.4° F prior to May 22 for steelhead smolts, < 59.0° F prior to June 4 for coho salmon smolts, and <62.6° F prior to July 9 for chinook salmon smolts.
Dry and Critically Dry	Provide the greatest amount of spawning and rearing microhabitat for anadromous salmonids in the existing channel, given the needs of the various life-stages.	Provide suitable temperatures for holding spring chinook and spawning spring and fall chinook by meeting temperature standards of: <60° F from July 1 to September 14 at Douglas City (RM 93.7), <56° F from September 15 to September 30 at Douglas City, and <56° F from October 1 to December 31 at the North Fork Trinity River confluence (RM 72.4). Facilitate early outmigration of smolts by allowing water temperatures to warm and provide at least marginal temperatures for anadromous salmonids throughout most of their outmigration by meeting temperature targets at Weitchpec (RM 0.0) of <59.0° F prior to May 22 for steelhead smolts, <62.6° F prior to June 4 for coho salmon smolts, and <68.0° F prior to July 9 for chinook salmon smolts.

alternate bars. The recession hydrograph components in Normal, Dry, and Critically Dry water-year classes also mimic unimpaired receding snowmelt rates (Appendix J).

Another "bench" in Extremely Wet, Wet, and Normal water years at a release of 2,000 cfs has two purposes: (1) to inundate exposed portions of alternate bars when seeds are viable and tributaries are contributing significant baseflows (refer to Attribute No. 9); and (2) to facilitate chinook smolt outmigration through July 9 (Figure 8.2). Similarly, a 36-day bench of 1,500 cfs in Critically Dry water years will discourage seedling germination on alternate bar flanks through inundation and will improve water temperatures for salmonids.

8.1.2.3 <u>Water Temperature Management Objectives</u>

Summer/Fall Temperature Control Flows

In 1991, the CRWQCB-NCR, in conjunction with the Service, CDFG, and the Hoopa Valley Tribe, established water-temperature objectives for the Trinity River to protect holding/spawning spring-run chinook salmon and spawning fall-run chinook salmon (Section 5.5). From July through mid-October a release of at least 450 cfs provides suitable water temperatures for holding and spawning spring-run chinook salmon and spawning fall-run chinook salmon in the Trinity River, above the confluence with the North Fork Trinity River (Figure 8.2; Section 5.5). Under a variety of hydro-meteorological

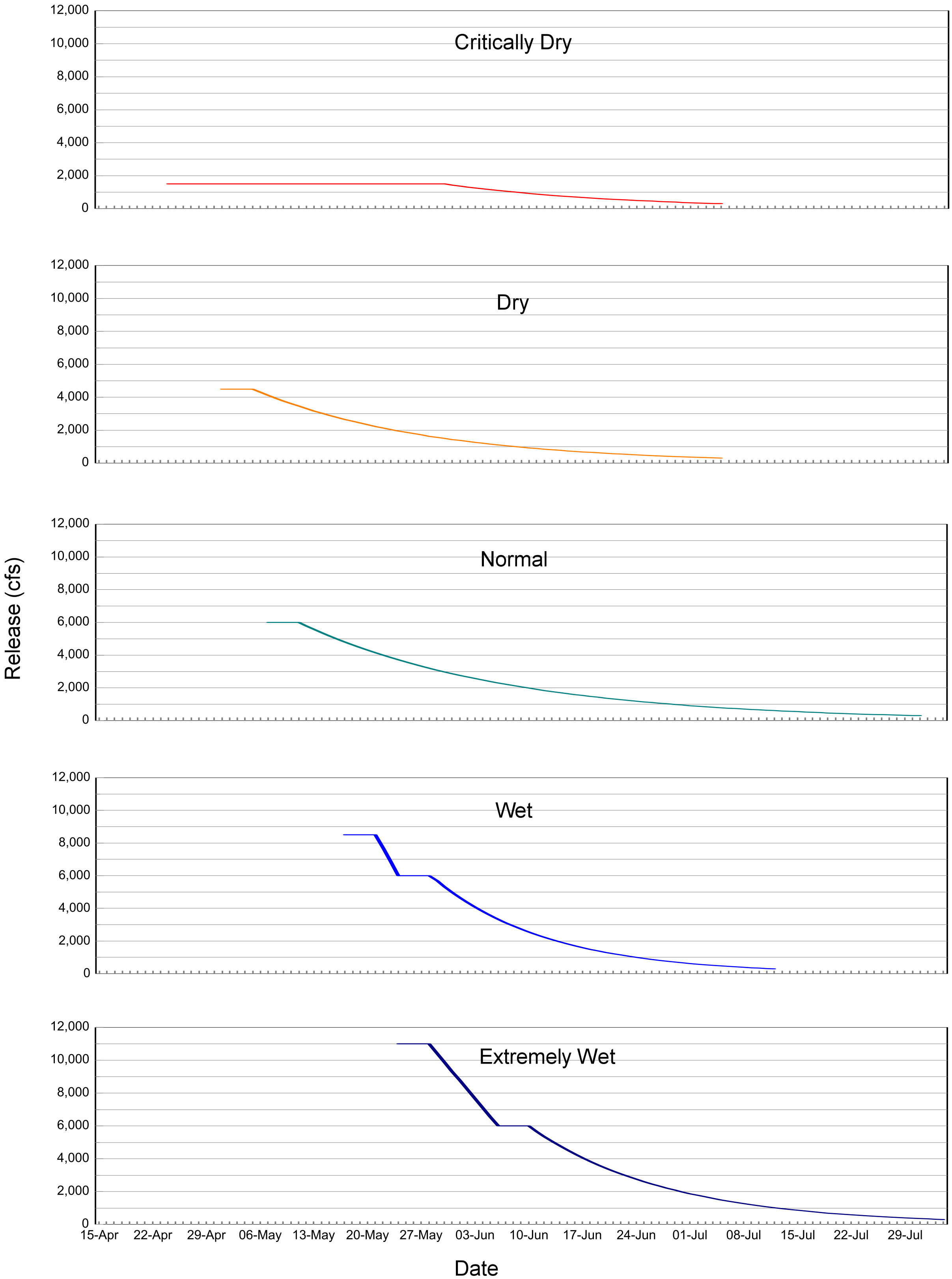

Figure 8.1. Lewiston Dam releases necessary to meet fluvial geomorphic objectives for each water-year class.

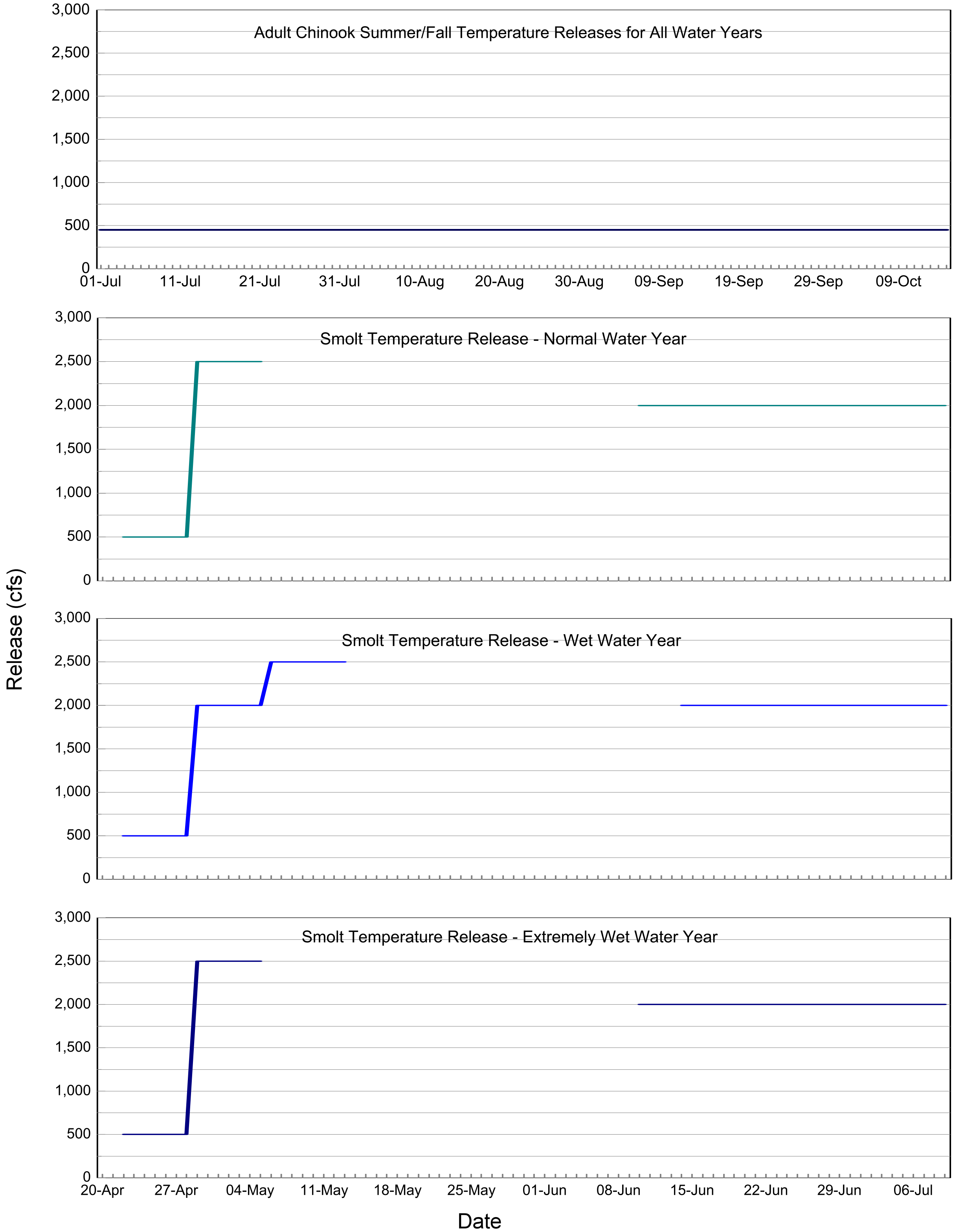

Figure 8.2. Lewiston Dam releases necessary to meet summer/fall adult chinook temperature objectives above the North Fork Trinity River confluence, and releases necessary to meet salmonid smolt temperature objectives at Weitchpec during Normal, Wet, and Extremely Wet water years. Releases for the time periods not graphed are covered by the fluvial geomorphic peaks.

conditions and dam release-water temperatures, releases of 450 cfs have met the temperature objectives established by the CRWQCB-NCR.

Salmonid Smolt Outmigration Flows

Because of the protracted outmigration period of the three anadromous salmonid species in the Trinity River, a variety of outmigrant temperature conditions are necessary throughout the spring/summer hydrographs (Chapter 5.5). Releases for the three water-year classes (Extremely Wet, Wet, and Normal) were scheduled to meet optimum salmonid smolt temperature criteria (Figure 8.2; Chapter 5.5). Because the timing of smolt outmigrations is similar to the timing of the recommended fluvial geomorphic releases, appropriate thermal regimes were provided under the fluvial geomorphic recommendation for much of the fluvial geomorphic hydrograph. Hydrographs were developed to meet optimal smolt temperatures prior to and at the end of the fluvial geomorphic releases during the Extremely Wet, Wet, and Normal water years (Appendix K).

> "Under a variety of hydrometeorological conditions and dam release-water temperatures, releases of 450 cfs have met the temperature objectives established by the CRWQCB-NCR."

Optimal smolt outmigration temperatures will not be provided during Dry and Critically Dry water years. The magnitude and timing of fluvial geomorphic releases during the Dry and Critically Dry water year hydrographs provided at least marginal salmonid smolt temperatures throughout much of the outmigration period (Appendix K). The lower geomorphic releases for these water-year classes provide flow and temperature conditions in the mainstem similar to those that exist lower in the Trinity River and in the lower Klamath River during these year classes (Appendix L). Allowing mainstem water temperatures to warm earlier in the outmigration period will cue salmonids to outmigrate before water temperatures in the lower watershed are likely to become too warm to ensure smolt survival.

> "Because of the protracted outmigration period of the three salmonid species in the Trinity River, a variety of outmigrant temperature conditions are necessary throughout the spring/summer hydrographs."

8.1.3 Assembly of Annual Hydrographs for Each Water Year

Annual hydrographs were assembled for each water class on the basis of the targeted microhabitat, fluvial processes (Figure 8.1), and desired temperature conditions (Figure 8.2). Total annual instream volumes, based on the recommended releases for each water-year class, ranged from 369 to 815 TAF (Table 8.4). Stepwise assembly of the Wet water year releases illustrates how management objectives were integrated into a single recommended release schedule (Figure 8.3). Throughout the year, a minimum recommended release of 300 cfs is required for spawning and rearing microhabitat. However, summer/fall temperature objectives require a greater release (450 cfs), which override the rearing microhabitat objectives in the summer and early fall. The benefits of providing suitable temperature regimes (as well as geomorphic processes) outweigh the short-term decrease in the amount of microhabitat. Similarly, smolt temperature objectives and the snowmelt peak and recession override rearing habitat objectives in the spring. The releases required to meet the snowmelt hydrograph also meet most of the smolt temperature objectives. The snowmelt ascending and receding limbs were modified in selected weeks as necessary to meet temperatures for steelhead smolt outmigration that were not initially met by the snowmelt hydrograph releases.

Table 8.4. Recommended annual water volumes for instream release to the Trinity River in thousands of acre-feet (TAF).

Water-Year Class	Instream Volume
Extremely Wet	815.2
Wet	701.0
Normal	646.9
Dry	452.6
Critically Dry	368.6
Average (weighted by water-year probability)	594.5

8.1.4 Recommended Release Schedules for Each Water-Year Class

Recommended daily releases from Lewiston Dam for each water-year class are presented in Appendix M.

8.1.4.1 Extremely Wet Water Year
(Table 8.5; Figure 8.4)

A release of 450 cfs from October 1 through October 15 maintains water temperatures suitable for spawning spring-run chinook salmon and holding fall-run chinook salmon in the Trinity River above the confluence with the North Fork Trinity River. Under a variety of hydrometeorological conditions and dam release-water temperatures, releases of 450 cfs have met the temperature objectives established by the CRWQCB-NCR.

A release of 300 cfs from October 16 through April 21 provides suitable microhabitat for spawning and rearing chinook salmon, coho salmon, and steelhead within the existing channel (Table 8.5, Figure 8.4). A 300-cfs release provides more microhabitat for most salmonid life-stages than does the 450-cfs release, which is required from July to mid-October for temperature control. Although spawning microhabitat is greater at low releases, reducing releases below 300 cfs would increase the occurrence of dewatering spring-run chinook redds constructed during the preceding 450-cfs release. Maintaining a 300-cfs release protects early life stages of salmonids throughout the protracted period of incubation and emergence that occurs in the mainstem resulting from the successive and extended spawning of chinook salmon, coho salmon, and steelhead.

A release of 500 cfs from April 22 through April 28 provides optimal temperatures for steelhead (<55.4° F), as well as for coho salmon (<59.0° F) and chinook salmon (<62.6° F) smolts.

A release of 1,500 cfs from April 29 through May 5 provides optimal temperatures for steelhead, coho salmon, and chinook salmon smolts throughout the mainstem.

"Annual hydrographs were assembled for each water class on the basis of the targeted microhabitat, fluvial processes, and desired temperature conditions."

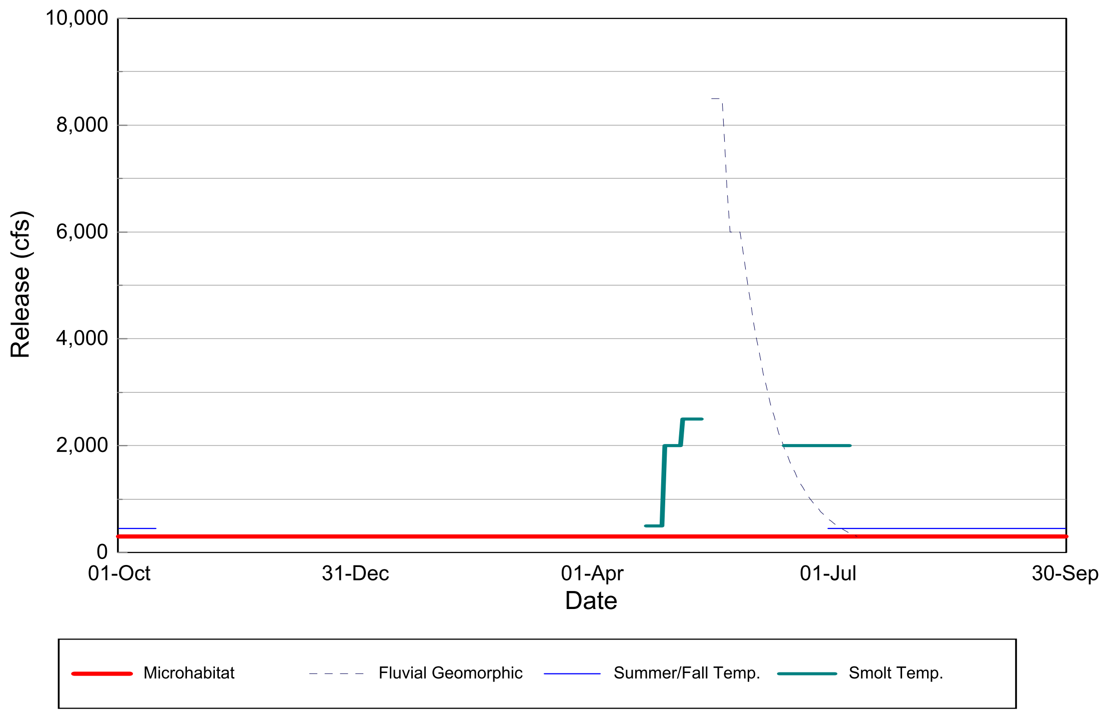

Figure 8.3. Releases necessary to meet microhabitat, fluvial geomorphic, summer/fall temperature, and smolt temperature management objectives during a Wet water year.

A release of 2,000 cfs from May 6 through May 19 provides optimal temperatures for steelhead, coho salmon, and chinook salmon smolts throughout the mainstem.

Recommended releases are increased from 2,000 cfs on May 19 to 11,000 cfs on May 24 to meet fluvial geomorphic objectives for the Extremely Wet water year. This ascending limb of the hydrograph is steep, simulating historical rain-on-snow events (McBain and Trush, 1997).

A 5-day peak release of 11,000 cfs from May 24 to May 28 targets fluvial geomorphic processes that will create major alterations in the channel and channelbed. This release magnitude and duration will mobilize most alluvial features, scour the channelbed to a depth >2D_{84}, transport sediment and route bedload, cause mortality of channel-encroaching plants and prevent germination of riparian plants, promote periodic channel migration and avulsion, and build floodplain features. The timing of the fluvial geomorphic peak release mimics the historical timing of snowmelt peaks during Extremely Wet water years. This release magnitude will also provide optimal temperatures for coho salmon and chinook salmon smolts throughout the mainstem.

Recommended releases decrease from 11,000 cfs on May 28 to 6,000 cfs on June 6. This rapid decrease mimics historical conditions that followed spring peak flows.

A 5-day release of 6,000 cfs from June 6 to June 10 facilitates the transport of fine bed material (sand) once higher flows have

"A 5-day peak release of 11,000 cfs . . . targets fluvial geomorphic processes that will create major alterations in the channel and channelbed."

Table 8.5. Recommended releases from Lewiston Dam with management targets, purpose, and benefits during an Extremely Wet water year.

Date	Release (cfs)	Hydrograph Component	Management Target	Purpose	Benefits
Oct 1 - Oct 15	450	Fall baseflow	≤ 56º F at confluence of the North Fork Trinity River	Provide optimal holding/spawning temperatures for spring- and fall- run chinook adults	Provide suitable temperatures, reducing pre-spawning mortality and increasing egg viability
Oct 16 - Apr 21	300	Winter baseflow	Provide maximum amount of spawning habitat	Provide best balance of spawning and rearing habitats for all anadromous salmonids in the existing channel	Increase spawning and rearing habitat while minimizing dewatering of redds (dewater less than 5% of redds) of salmonids
Apr 22 - Apr 28	500	Spring baseflow	≤ 55.4º F at Weitchpec	Provide optimal temperatures for survival of steelhead smolts	Improve steelhead smolt production
Apr 29 - May 5	1,500	Spring baseflow/ Ascending limb	≤ 55.4º F at Weitchpec	Provide optimal temperatures for survival of steelhead smolts	Improve steelhead smolt production
May 6 - May 19	2,000	Spring baseflow/ Ascending limb	≤ 55.4º F at Weitchpec	Provide optimal temperatures for survival of steelhead smolts	Improve steelhead smolt production Reduce travel time of outmigrating steelhead smolts
May 19 - May 24	2,000 - 11,000	Ascending limb	Reach peak flow	Ramp to peak flow (according to OCAP) safely for human use	Reduce travel time of outmigrating steelhead smolts
May 24 - May 28	11,000	Snowmelt peak	Peak: Mobilize ≥2 D_{84} deep on flanks of alternate bars (more on lower channel than upper) cleanses gravels and transports all sizes of sediments Initiate channel migration at bank rehabilitation sites Duration: Transport coarse sediment (>5/16 inch) through mainstem at a rate equal to the tributary input downstream of Rush Creek Transport fine sediment (<5/16 inch) through mainstem at a rate greater than tributary input (as measured at Limekiln Gulch Gaging Station)	Reduce fine sediment (<5/16 inch) storage within the surface and subsurface chnnelbed Increase sinuousity through channel migration Create and maintain alternate bar morphology Create floodplains by bar building and fine sediment deposition Encourage establishment and growth of riparian vegetation on floodplains Scour up to 3 yr old woody riparian vegetation along low flow channel margins and scour younger plants higher on bar flanks	Increase fry production through improved egg-to-emergence success Increase fry production by creating and maintaining rearing habitat along channel margins Increase smolt production by increasing year-round rearing habitat quality and quantitiy, and reducing outmigration travel time Increase species and age diversity of riparian vegetation

Table 8.5. Continued.

Date	Release (cfs)	Hydrograph Component	Management Target	Purpose	Benefits
May 28 - Jun 6	11,000 - 6,000	Descending limb	Ramp to 6,000 cfs	Reduce fine sediment (<5/16 inch) storage within surface channelbed	Increase fry production through improved egg-to-emergence success
Jun 6 - Jun 10	6,000	Descending limb bench	Transport fine sediment (<5/16 inch) through mainstem at a rate greater than tributary input (as measured at Limekiln Gulch Gaging Station)	Reduce fine sediment (<5/16 inch) storage within surface channelbed while minimizing coarse sediment (>5/16 inch) transport	Improve fry production through improved egg-to-emergence success Discourage riparian vegetation initiation along low water channel margins
Jun 10 - Jun 30	6,000 - 2,000	Descending limb	Descend at a rate mimicking pre-TRD descent	Inundate point bars Minimize river stage change to preserve egg masses of yellow legged frogs Maintain seasonally variable water surface levels in side channels and off-channel wetlands	Prevent riparian vegetation initiation along low water channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile chinook salmon growth Increase riparian vegetation and future LWD recruitment
Jun 30 - Jul 9	2,000	Descending limb bench	Provide optimal water temperatures ($\leq$ 62.6º F) to Weitchpec for chinook salmon smolts	Provide optimal temperatures for increased survival of chinook smolts Inundate point bars	Improve chinook smolt production Prevent riparian initiation along low water channel margins
Jul 9 - Jul 22	2,000 - 450	Descending limb	Decline to summer baseflow	Minimize stranding of salmonid fry behind berms	Increase survival of steelhead fry Provide outmigration cues for chinook smolts
Jul 22 - Sep 30	450	Summer baseflow	Provide water temperatures $\leq$ 60º F to Douglas City through Sep 14 Provide water temperatures $\leq$ 56º F to Douglas City from Sep 15 through Sep 30	Increase survival of holding adult spring-run chinook by providing optimal thermal refugia	Increase production of coho salmon and steelhead by providing water temperatures conducive to growth

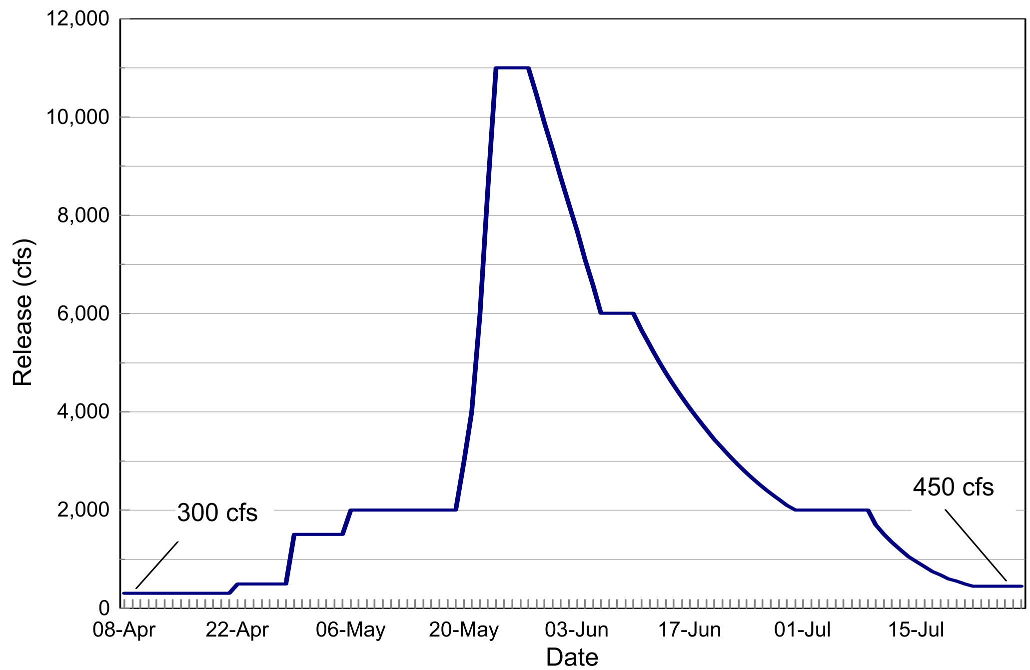

Figure 8.4. Recommended releases during an Extremely Wet water year. Releases are scheduled for 450 cfs from July 22 to October 15. Releases are scheduled for 300 cfs from October 16 to April 21.

mobilized the surface layer of the general channelbed and alternate bars, while minimizing transport of coarse bed material. This release will transport fine sediment (sand), cause mortality of riparian vegetation seedlings, and inundate the flanks of bars to discourage germination and prevent encroachment of riparian plants. This release provides optimal temperatures for chinook salmon smolts throughout the mainstem.

Recommended releases gradually decrease from 6,000 cfs on June 10 to 2,000 cfs on June 30. The rate of this decrease mimics historical conditions that followed spring flows of approximately 6,000 cfs during Extremely Wet water years. Releases during the descending limb of the Extremely Wet water year hydrograph transport fine sediment (sand) and inundate alternate bar features, cause mortality of riparian vegetation seedlings and prevent germination and encroachment on lower bar surfaces, and encourage natural riparian regenerataion on upper bar surfaces and floodplains. These release magnitudes provide optimal temperatures for chinook salmon smolts throughout the mainstem.

A release of 2,000 cfs from June 30 to July 9 provides optimal temperatures for chinook salmon smolts throughout the mainstem. Alternate bar features will be inundated, causing mortality of riparian vegetation seedlings and preventing germination of riparian vegetation on lower bar surfaces. Some fine sediment (sand) transport occurs at this release magnitude.

"Releases during the descending limb of the Extremely Wet water year hydrograph transport fine sediment (sand) and inundate alternate bar features, cause mortality of riparian vegetation seedlings and prevent germination and encroachment on bar surfaces."

> "The gradual decrease [from 2,000 to 450 cfs] minimizes stranding potential of fry and juvenile salmonids and allows gradual warming of the mainstem to provide outmigration cues to any remaining smolts."

Recommended releases decrease from 2,000 cfs on July 9 to 450 cfs on July 22 to reach summer temperature-control releases. The gradual decrease minimizes stranding of fry and juvenile salmonids and allows gradual warming of the mainstem to provide outmigration cues to any remaining smolts.

A release of 450 cfs from July through September 30 maintains suitable water temperatures for holding and spawning spring-run chinook salmon in the Trinity River above the confluence with the North Fork Trinity River.

8.1.4.2 <u>Wet Water Year</u> (Table 8.6; Figure 8.5)

A release of 450 cfs from October 1 through October 15 maintains water temperatures suitable for spawning spring-run chinook salmon and holding fall-run chinook salmon in the Trinity River above the confluence with the North Fork Trinity River.

A release of 300 cfs from October 16 through April 21 provides suitable microhabitat for spawning and rearing chinook salmon, coho salmon, and steelhead within the existing channel.

A release of 500 cfs from April 22 through April 28 provides optimal temperatures for steelhead, coho salmon, and chinook salmon smolts throughout most of the mainstem.

A release of 2,000 cfs from April 29 through May 5 provides optimal temperatures for steelhead, coho salmon, and chinook salmon smolts throughout most of the mainstem.

A release of 2,500 cfs from May 6 through May 13 provides optimal temperatures for steelhead, coho salmon, and chinook salmon smolts throughout the mainstem.

Recommended releases increase from 2,500 cfs on May 13 to 8,500 cfs on May 17 to meet fluvial geomorphic objectives for the Wet water year. This ascending limb of the hydrograph is steep, simulating historical rain-on-snow events (McBain and Trush, 1997).

A 5-day peak release of 8,500 cfs from May 17 to May 21 targets several fluvial geomorphic processes. This release magnitude and duration will mobilize most alluvial features, scour channelbed to a depth $>1D_{84,}$ transport fine sediment and route bedload, cause mortality of channel-encroaching plants and prevent germination on bar surfaces, initiate periodic channel migration, and inundate/create floodplains. The timing of the fluvial geomorphic peak release mimics the historical timing of the snowmelt peak during wet water years. This release provides optimal temperatures for steelhead, coho salmon, and chinook salmon smolts throughout the mainstem.

> "A 5-day peak release of 8,500 cfs . . . targets several fluvial geomorphic processes [that will] mobilize most alluvial features, scour channelbed to a depth $>1D_{84,}$ transport fine sediment and route bedload, cause mortality of channel-encroaching plants and prevent germination on bar surfaces, initiate periodic channel migration, and inundate/create floodplains."

Recommended releases decrease from 8,500 cfs on May 21 to 6,000 cfs on May 24. This rapid decrease mimics historical conditions that followed spring peak flows.

A 5-day release of 6,000 cfs from May 24 to May 28 facilitates the transport of fine bed material (sand) once higher flows have mobilized the coarse surface layer of the

Table 8.6. Recommended releases from Lewiston Dam with management targets, purpose, and benefits during a Wet water year.

Date	Release (cfs)	Hydrograph Component	Management Target	Purpose	Benefits
Oct 1 - Oct 15	450	Fall baseflow	≤ 56º F at confluence of the North Fork Trinity River	Provide optimal holding/spawning temperatures for spring- and fall- run chinook adults	Provide suitable temperatures, reducing pre-spawning mortality and increasing egg viability
Oct 16 - Apr 21	300	Winter baseflow	Provide maximum amount of spawning habitat	Provide best balance of spawning and rearing habitats for all anadromous salmonids in the existing channel	Increase spawning and rearing habitat while minimizing dewatering of redds (dewater less than 5% of redds) of salmonids
Apr 22 - Apr 28	500	Spring baseflow	≤ 55.4º F to Weitchpec	Provide optimal temperatures for survival of steelhead smolts	Improve steelhead smolt production
Apr 29 - May 5	2,000	Spring baseflow/ Ascending limb	≤ 55.4º F to Weitchpec	Provide optimal temperatures for survival of steelhead smolts	Improve steelhead smolt production
May 6 - May 13	2,500	Spring baseflow/ Ascending limb	≤ 55.4º F to Weitchpec	Provide optimal temperatures for survival of steelhead smolts	Improve steelhead smolt production Reduce travel time of outmigrating steelhead smolts
May13 - May 17	2,500 - 8,500	Ascending limb	Reach peak flow	Ramp to peak flow (according to OCAP) safely for human use	Reduce travel time of outmigrating steelhead smolts
May 17 - May 21	8,500	Snowmelt peak	Peak Threshold : Mobilize ≥1 D_{84} deep on flanks of alternate bars (more on lower channel than on upper) cleanses gravels and transports all sizes of sediments Initiate channel migration at bank rehabilitation sites Duration:Transport coarse sediment (>5/16 inch) through mainstem at a rate equal to tributary input downstream of Rush Creek Transport fine sediment (<5/16 inch) through mainstem at a rate greater than tributary input (as measured at Limekiln Gulch Gaging Station)	Reduce fine sediment (<5/16 inch) storage within surface and subsurface channelbed Increase sinuousity through channel migration Create and maintain alternate bar morphology Create floodplains by bar building and fine sediment deposition Encourage establishment and growth of riparian vegetation on floodplains Scour up to 2 yr old woody riparian vegetation along low flow channel margins	Increase fry production through improved egg-to-emergence success Increase fry production by creating and maintaining rearing habitat along channel margins Increase smolt production by increasing year-round habitat quality and quantity and reducing outmigration travel time Increase species and age diversity of riparian vegetation

Table 8.6. Continued.

Date	Release (cfs)	Hydrograph Component	Management Target	Purpose	Benefits
May 21 - May 24	8,500 - 6,000	Descending limb	Ramp to 6,000 cfs	Reduce fine sediment (<5/16 inch) storage within surface channelbed	Increase fry production through improved egg-to-emergence success
May 24 - May 28	6,000	Descending limb bench	Transport fine sediment (<5/16 inch) through mainstem at a rate greater than tributary input (as measured at Limekiln Gulch Gaging Station)	Reduce fine sediment (<5/16 inch) storage within surface channelbed while minimizing coarse sediment (>5/16 inch) transport	Increase fry production through improved egg-to-emergence success Discourage riparian vegetation initiation along low water channel margins
May 28 - Jun 14	6,000 - 2,000	Descending limb	Descend at a rate mimicking pre-TRD descent Descend at a rate less than 0.1 ft/day	Inundate point bars Minimize river stage change to preserve egg masses of yellow legged frogs Maintain seasonally variable water surface levels in side channels and off-channel wetlands	Prevent riparian vegetation initiation along low water channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile chinook salmon growth
Jun 14 - Jul 9	2,000	Descending limb bench	Provide optimal water temperatures ($\leq$62.6º F) to Weitchpec for chinook salmon smolts	Provide optimal temperatures for increased survival of chinook smolts Inundate point bars	Improve chinook smolt production Prevent riparian initiation along low water channel margins
Jul 9 - Jul 22	2,000 - 450	Descending limb	Decline to summer baseflow	Minimize stranding of salmonid fry behind berms	Increase survival of steelhead fry Provide outmigration cues for chinook smolts
Jul 22 - Sep 30	450	Summer baseflow	Provide water temperatures $\leq$ 60º F to Douglas City through Sep 14 Provide water temperatures $\leq$ 56º F to Douglas City from Sep 15 through Sep 30	Increase survival of holding adult spring-run chinook by providing optimal thermal refugia	Increase production of coho salmon and steelhead by providing water temperatures conducive to growth

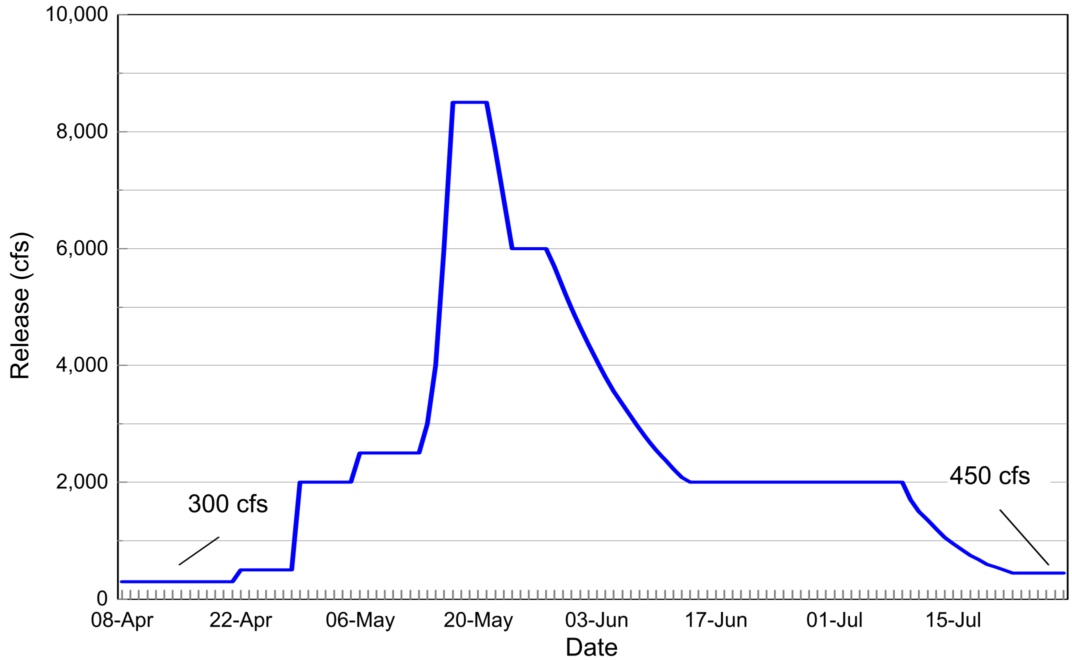

Figure 8.5. Recommended releases during a Wet water year. Releases are scheduled for 450 cfs from July 22 to October 15. Releases are scheduled for 300 cfs from October 16 to April 21.

general channelbed and alternate bars, while minimizing transport of coarse bed material. This release will transport fine sediment (sand), cause mortality of riparian vegetation seedlings, and inundate the flanks of bars to discourage germination and prevent encroachment of riparian plants. This release provides optimal temperatures for chinook salmon smolts throughout the mainstem.

Recommended releases gradually decrease from 6,000 cfs on May 28 to 2,000 cfs on June 14. The rate of this decrease mimics historical conditions that followed spring flows of approximately 6,000 cfs during Wet water years. Releases during the descending limb of the wet water year hydrograph transport fine sediment (sand) and inundate alternate bar features, causing mortality of riparian seedlings and preventing germination and encroachment on bar surfaces. During this period, release magnitudes provide optimal temperatures for coho salmon and chinook salmon smolts throughout the mainstem.

A release of 2,000 cfs from June 14 to July 9 provides optimal temperatures for chinook salmon smolts throughout the mainstem and for salmonid rearing temperatures throughout most of the mainstem. Alternate bar features will be inundated, causing mortality of riparian seedlings and preventing germination of riparian plants on lower bar surfaces. Some fine sediment (sand) transport occurs at this release.

Recommended releases decrease from 2,000 cfs on July 9 to 450 cfs on July 22 to reach summer temperature-control releases. The gradual decrease minimizes stranding potential of fry and juvenile salmonids and allows gradual warming of the mainstem to provide outmigration cues to any remaining smolts.

A release of 450 cfs from July 22 through September 30 maintains suitable water temperatures for holding and spawning spring-run chinook salmon in the Trinity River above the confluence with the North Fork Trinity River.

8.1.4.3 **Normal Water Year** (Table 8.7; Figure 8.6)

A release of 450 cfs from October 1 through October 15 maintains water temperatures suitable for spawning spring-run chinook salmon and holding fall-run chinook salmon in the Trinity River above the confluence with the North Fork Trinity River.

A release of 300 cfs from October 16 through April 21 provides suitable microhabitat for spawning and rearing chinook salmon, coho salmon, and steelhead within the existing channel.

> "A 5-day release of 6,000 cfs . . . mobilizes most alluvial features, transports fine sediment (sand), causes mortality of riparian seedlings and prevents germination on bar surfaces, and inundates floodplains."

A release of 500 cfs from April 22 through April 28 provides optimal temperatures for steelhead, coho salmon, and chinook salmon smolts.

A release of 2,500 cfs from April 29 through May 5 provides optimal temperatures for steelhead, coho salmon, and chinook salmon smolts.

Recommended releases increase from 2,500 cfs on May 5 to 6,000 cfs on May 7 to meet fluvial geomorphic objectives for the Normal water year. This ascending limb of the hydrograph is steep, simulating historical rain-on-snow events (McBain and Trush, 1997).

A 5-day release of 6,000 cfs from May 7 to May 11 targets fluvial geomorphic processes. This release magnitude and duration mobilizes most alluvial features, transports fine sediment (sand), causes mortality of riparian seedlings and prevents germination on bar surfaces, and inundates floodplains. The timing of the fluvial geomorphic peak mimics the historical timing of the snowmelt peak during Normal water years. This release magnitude provides optimal temperatures for steelhead, coho salmon, and chinook salmon smolts throughout the mainstem.

Recommended releases gradually decrease from 6,000 cfs on May 11 to 2,000 cfs on June 10. The rate of this decrease mimics historical decreases in flow that followed spring flows of approximately 6,000 cfs during normal water years. Releases during the descending limb of the normal water year hydrograph transport fine sediment (sand) and inundate alternate bar features, causing mortality of riparian seedlings and preventing germination and encroachment on bar surfaces. During this period, releases provide optimal temperatures for steelhead, coho salmon, and chinook salmon smolts throughout the mainstem.

A release of 2,000 cfs from June 10 to July 9 provides optimal temperatures for rearing steelhead, and coho salmon and chinook salmon smolts throughout the mainstem. Alternate bar features will be inundated, causing mortality of riparian seedlings and preventing germination of riparian plants on lower bar surfaces. Some fine sediment (sand) transport occurs at this release magnitude.

Recommended releases decrease from 2,000 cfs on July 9 to 450 cfs on July 22 to reach summer temperature-control releases. The gradual decrease minimizes stranding of fry and juvenile salmonids and allows gradual warming of the mainstem to provide outmigration cues to any remaining smolts.

A release of 450 cfs from July 22 through September 30 maintains suitable water temperatures for holding and spawning spring-run chinook salmon in the Trinity River above the confluence with the North Fork Trinity River.

Table 8.7. Recommended releases from Lewiston Dam with management targets, purpose, and benefits during a Normal water year.

Date	Release (cfs)	Hydrograph Component	Management Target	Purpose	Benefits
Oct 1 - Oct 15	450	Fall baseflow	≤ 56º F at confluence of the North Fork Trinity River	Provide optimal holding/spawning temperatures for spring- and fall- run chinook adults	Provide suitable temperatures, reducing pre-spawning mortality and increasing egg viability
Oct 16 - Apr 21	300	Winter baseflow	Provide maximum amount of spawning habitat	Provide best balance of spawning and rearing habitats for all anadromous salmonids in the existing channel	Increase spawning and rearing habitat while minimizing dewatering of redds (dewater less than 5% of redds) of salmonids
Apr 22 - Apr 28	500	Spring baseflow	≤ 55.4º F at Weitchpec	Provide optimal temperatures for enhanced survival of steelhead smolts	Improve steelhead smolt production
Apr 29 - May 5	2,500	Spring baseflow/ Ascending limb	≤ 55.4º F at Weitchpec	Provide optimal temperatures for enhanced survival of steelhead smolts	Improve steelhead smolt production
May 5 - May 7	2,500 - 6,000	Ascending limb	Reach peak flow	Ramp to peak flow (according to OCAP) safely for human use Provide optimal temperatures for survival of steelhead smolts	Reduce travel time of outmigrating steelhead smolts Improve steelhead smolt production
May 7 - May 11	6,000	Snowmelt peak	<u>Peak Threshold</u>: Mobilize D_{84} on most alluvial features (general channel mobility) <u>Duration</u>: Transport coarse sediment (>5/16 inch) through mainstem at a rate equal to the tributary input downstream of Rush Creek Transport fine sediment (<5/16 inch) through mainstem at a rate greater than tributary input (as measured at Limekiln Gulch Gaging Station)	Reduce fine sediment (<5/16 inch) storage within the surface channelbed Create and maintain alternate bar morphology Create floodplains by bar building and fine sediment deposition Encourage establishment and growth of riparian vegetation on floodplains Scour up to 1 yr old woody riparian vegetation along channel margins	Increase fry production through improved egg-to-emergence success Discourage riparian vegetation initiation along low water channel margins Increase smolt production by increasing year-round rearing habitat quality and quantity, and reducing outmigration transport time

Table 8.7. Continued.

Date	Release (cfs)	Hydrograph Component	Management Target	Purpose	Benefits
May 11 - Jun 10	6,000 - 2,000	Descending limb	Descend at a rate mimicking pre-TRD descent Descend at a rate less than 0.1 ft/day	Inundate point bars to prevent riparian initiation and encroachment along channel margins Minimize river stage change to preserve egg masses of yellow legged frogs Maintain seasonal variation of water surface levels in side channels and off-channel wetlands	Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile chinook growth Increase riparian vegetation and future LWD recruitment
Jun 10 - Jul 9	2,000	Descending limb bench	Provide optimal water temperatures ($\leq$ 62.6º F) to Weitchpec for chinook salmon smolts	Provide optimal water temperatures for survival of chinook salmon smolts Inundate point bars to prevent riparian initiation along channel margins	Improve chinook smolt production Prevent riparian initiation along channel margin
Jul 9 - Jul 22	2,000 - 450	Descending limb	Decline to summer baseflow	Minimize salmonid fry stranding behind berms	Increase survival of steelhead fry Provide outmigration cues for chinook salmon smolts
Jul 22 - Sep 30	450	Summer baseflow	Provide water temperatures $\leq$ 60º F to Douglas City through Sep 14 Provide water temperatures $\leq$ 56º F to Douglas City from Sep 15 through Sep 30	Increase survival of holding adult spring-run chinook by providing optimal thermal refugia	Increase production of coho salmon and steelhead by providing water temperatures conducive to growth

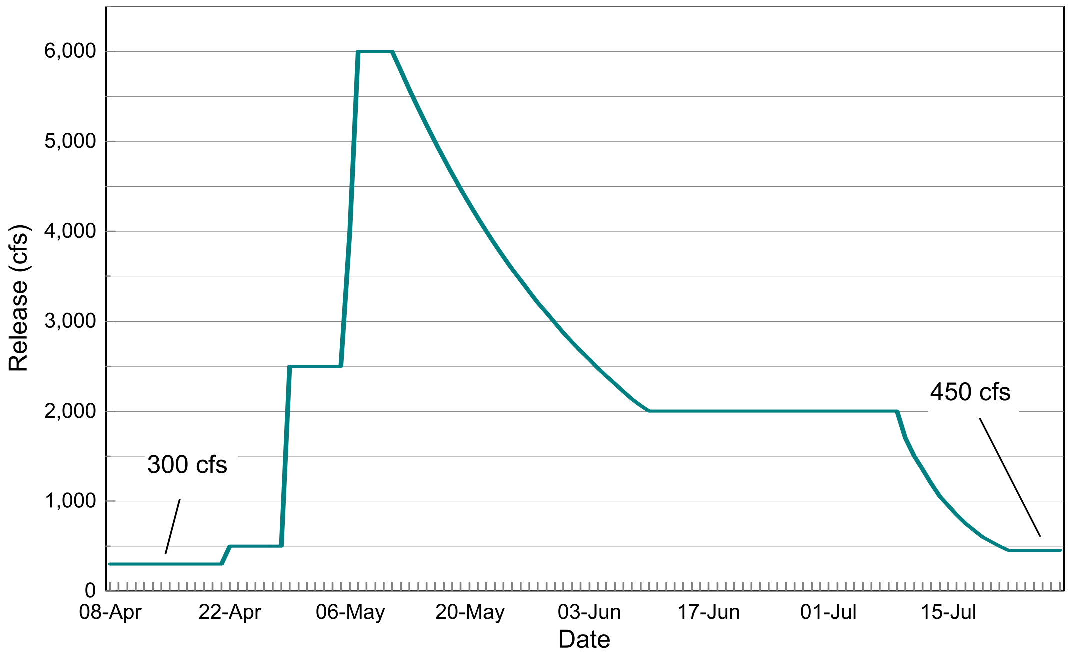

Figure 8.6. Recommended releases during a Normal water year. Releases are scheduled for 450 cfs from July 22 to October 15. Releases are scheduled for 300 cfs from October 16 to April 21.

8.1.4.4 Dry Water Year (Table 8.8; Figure 8.7)

A release of 450 cfs from October 1 through October 15 maintains water temperatures suitable for spawning spring-run chinook salmon and holding fall-run chinook salmon in the Trinity River above the confluence with the North Fork Trinity River.

A release of 300 cfs from October 16 through April 26 provides suitable microhabitat for spawning and rearing chinook salmon, coho salmon, and steelhead within the existing channel.

Recommended releases increase from 300 cfs on April 26 to 4,500 cfs on May 1 to meet fluvial geomorphic objectives for the Dry water year. This ascending limb of the hydrograph is steep, simulating historical rain-on-snow events (McBain and Trush, 1997).

> "A 5-day release of 4,500 cfs from May 1 to May 5 targets fluvial geomorphic processes . . . [that] mobilizes inchannel alluvial features, transports some fine sediment (sand), causes mortality of riparian seedlings, and prevents germination on bar surfaces."

A 5-day release of 4,500 cfs from May 1 to May 5 targets fluvial geomorphic processes. This release magnitude and duration mobilizes in-channel alluvial features, transports some fine sediment (sand), causes mortality of riparian seedlings, and prevents germination on bar surfaces. The timing of the fluvial geomorphic peak release mimics the historical timing of the snowmelt peak during Dry water years. This release provides at least marginal temperatures for steelhead, coho salmon, and chinook salmon smolts throughout the mainstem.

Releases gradually decrease from 4,500 cfs on May 5 to 450 cfs on June 26. The rate of this decrease mimics historical conditions that followed spring flows of approximately 4,500 cfs during Dry water years.

Table 8.8. Recommended releases from Lewiston Dam with management targets, purpose, and benefits during a Dry water year.

Date	Release (cfs)	Hydrograph Component	Management Target	Purpose	Benefits
Oct 1 - Oct 15	450	Fall baseflow	≤ 56º F at confluence of the North Fork Trinity River	Provide optimal holding/spawning temperatures for spring- and fall-run chinook adults	Provide suitable temperatures, reducing pre-spawning mortality and increasing egg viability
Oct 16 - Apr 26	300	Winter baseflow	Provide maximum amount of spawning habitat	Provide best balance of spawning and rearing habitats for all anadromous salmonids in the existing channel	Increase spawning and rearing habitat while minimizing dewatering of redds (dewater less than 5% of redds) of salmonids
Apr 26 - May 1	300 - 4,500	Ascending limb	Reach peak flow	Ramp to peak flow (according to OCAP) safely for human use	Reduce travel time of outmigrating steelhead smolts
May 1 - May 5	4,500	Peak flow	Peak Threshold: Mobilize D_{84} on bar flanks features (median bars, pool tails) Duration: Transport coarse sediment (>5/16 inch) through mainstem at a rate equal to the tributary input downstream of Rush Creek Transport fine sediment (<5/16 inch) through mainstem at a rate greater than tributary input (as measured at Limekiln Gulch Gaging Station)	Reduce fine sediment (<5/16 inch) storage within surface channelbed	Increase salmonid fry production through improved egg-to emergence success Discourage riparian vegetation initiation along low flow channel margins
May 5 - Jun 26	4,500 - 450	Descending limb	Descend at a rate mimicking pre-TRD descent Provide non-lethal water temperatures to Weitchpec for coho smolts (≤ 62.6º F) until June 4 , and for chinook smolts (≤ 68º F) until mid-June	Inundate point bars Minimize river stage change to preserve egg masses of yellow legged frogs Maintain seasonal variation of water surface levels in side channels and off-channel wetlands Improve salmonid smolt production by providing temperatures necessary for survival of steelhead, coho, chinook smolts	Prevent riparian initiation along channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile chinook growth Increase survival of steelhead fry Provide outmigration cues for chinook salmon smolts
Jun 26 - Sep 30	450	Summer baseflow	Provide water temperatures ≤ 60º F to Douglas City through Sep 14 Provide water temperatures ≤ 56º F to Douglas City from Sep 15 through Sep 30	Increase survival of holding adult spring-run chinook by providing optimal thermal refugia	Increase production of coho salmon and steelhead by providing water temperatures conducive to growth

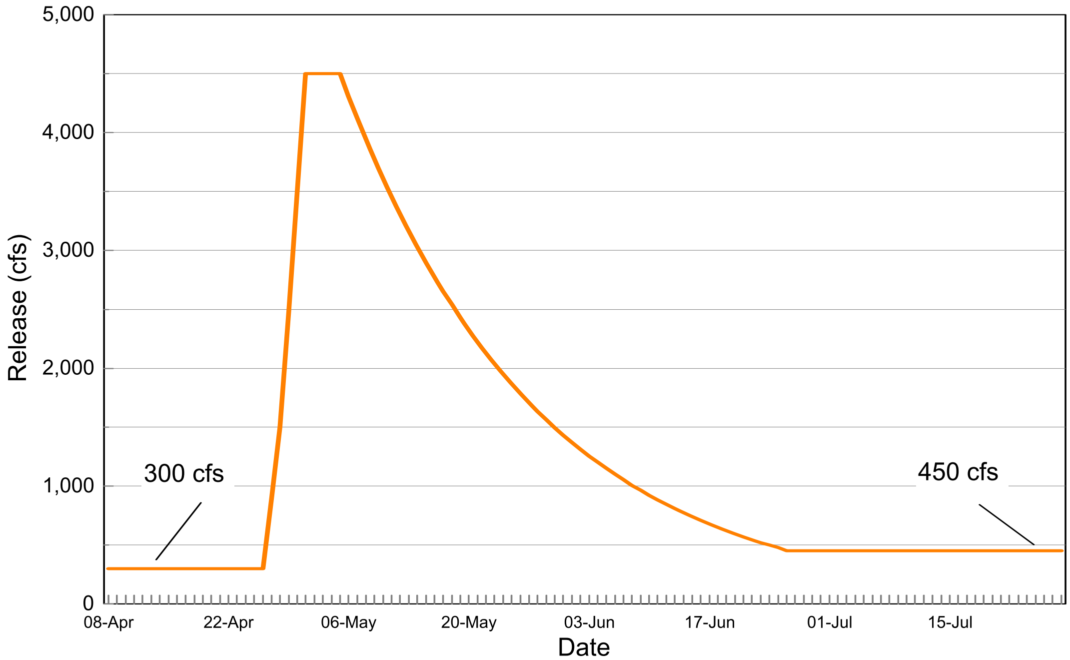

Figure 8.7. Recommended releases during a Dry water year. Releases are scheduled for 450 cfs from June 26 to October 15. Releases are scheduled for 300 cfs from October 16 to April 26.

Releases during much of the descending limb of the dry water year hydrograph inundate alternate bar features, causing mortality of riparian seedlings and preventing germination on bar surfaces, and transport small volumes of fine sediment (sand). The gradual reduction of releases minimizes stranding of fry and juvenile salmonids. Releases during this period provide at least marginal temperatures for coho salmon and chinook salmon smolts throughout the mainstem until mid-June. The gradual reduction of releases allows gradual warming of the mainstem to provide outmigration cues to any remaining smolts.

A release of 450 cfs from June 26 through September 30 maintains suitable water temperatures for holding and spawning spring-run chinook salmon in the Trinity River above the confluence with the North Fork Trinity River.

8.1.4.5 **Critically Dry Water Year** (Table 8.9; Figure 8.8)

A release of 450 cfs from October 1 through October 15 maintains water temperatures suitable for spawning spring-run chinook salmon and holding fall-run chinook salmon in the Trinity River above the confluence with the North Fork Trinity River.

A release of 300 cfs from October 16 through April 22 provides suitable microhabitat for spawning and rearing chinook salmon, coho salmon, and steelhead within the existing channel.

Recommended releases increase from 300 cfs on April 22 to 1,500 cfs on April 24 to attain peak release magnitudes for the Critically Dry water year. This ascending limb of the hydrograph is steep, simulating historical rain-on-snow events (McBain and Trush, 1997).

> "A 36-day peak release of 1,500 cfs . . . inundates most alternate bar surfaces, preventing germination of riparian plants for a portion of the seed-release period."

Table 8.9. Recommended releases from Lewiston Dam with management targets, purpose, and benefits during a Critically Dry water year.

Date	Release (cfs)	Hydrograph Component	Management Target	Purpose	Benefits
Oct 1 - Oct 15	450	Fall baseflow	≤ 56º F at confluence of the North Fork Trinity River	Provide optimal holding/spawning temperatures for spring- and fall-run chinook adults	Provide suitable temperatures, reducing pre-spawning mortality and increasing egg viability
Oct 16 - Apr 22	300	Winter baseflow	Provide maximum amount of spawning habitat	Provide best balance of spawning and rearing habitats for all anadromous salmonids in the existing channel	Increase spawning and rearing habitat while minimizing dewatering of redds (dewater less than 5% of redds) of salmonids
Apr 22 - Apr 24	300 - 1,500	Ascending limb	Reach peak flow	Ramp to peak flow (according to OCAP) safely for human use	Reduce travel time of outmigrating steelhead smolts
Apr 24 - Apr 29	1,500	Peak flow	Provide non-lethal water temperatures to Weitchpec for steelhead smolts (≤ 59º F) until May 22 , and for coho salmon smolts (≤ 62.6º F) until May 29 Inundate bar flanks (1,500 cfs)	Sustain steelhead and coho salmon smolt production by providing non-lethal temperatures for survival Discourage riparian vegetation establishment along channel margins	Transport limited amounts of surface fine sediment (<5/16 inch)
May 29 - Jun 26	1,500 - 450	Descending limb	Descend at a rate mimicking pre-TRD descent Provide non-lethal water temperatures to Weitchpec for coho smolts (≤ 62.6º F) until June 4, and for chinook smolts (≤ 68º F) until mid-June	Minimize river stage change to preserve egg masses of yellow legged frogs Inundate point bars Improve salmonid smolt production by providing temperatures necessary for survival of steelhead, coho, chinook smolts	Prevent riparian initiation along low water channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Maintain seasonal variable water surface levels in side channel and off-channel wetleands Sustain/ improve salmonid smolt production Provide outmigration cues for chinook salmon smolts
Jun 26 - Sep 30	450	Summer baseflow	Provide water temperatures ≤ 60º F to Douglas City through Sep 14 Provide water temperatures ≤ 56º F to Douglas City from Sep 15 through Sep 30	Increase survival of holding adult spring-run chinook by providing optimal thermal refugia	Increase production of coho salmon and steelhead by providing water temperatures conducive to growth

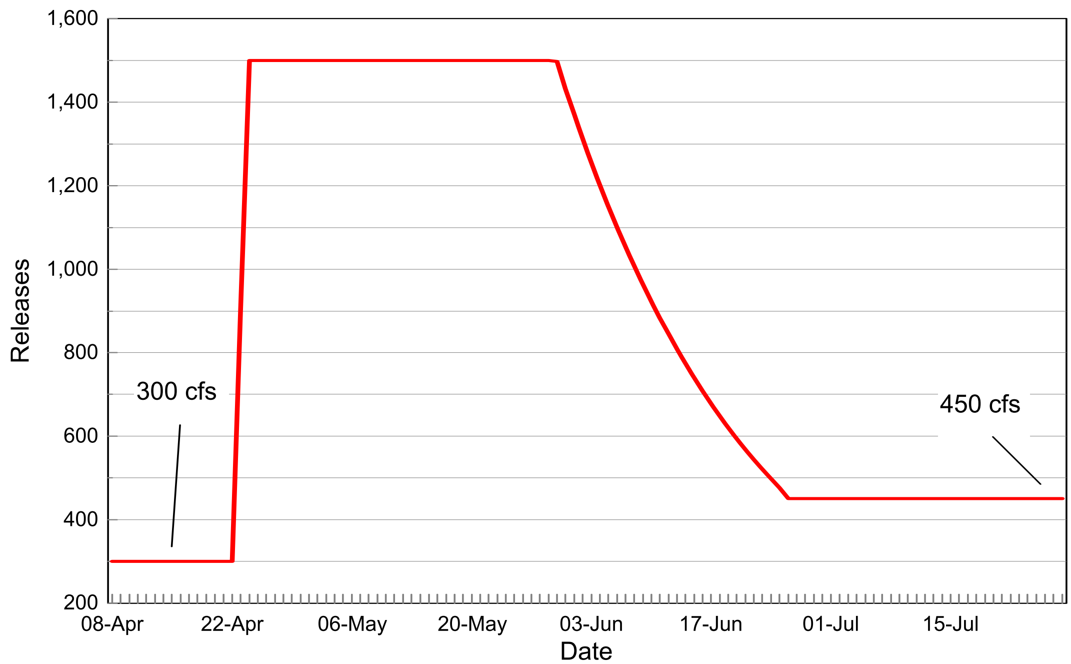

Figure 8.8. Recommended releases during a Critically Dry water year. Releases are scheduled for 450 cfs from June 26 to October 15. Releases are scheduled for 300 cfs from October 16 to April 22.

A 36-day peak release of 1,500 cfs from April 24 to May 29 inundates most alternate bar surfaces, preventing germination of riparian plants for a portion of the seed-release period. The timing of the fluvial geomorphic peak release mimics the historical timing of the snowmelt peak during Dry water years.

Releases gradually decrease from 1,500 cfs on May 29 to 450 cfs on June 26. The rate of this decrease mimics historical conditions during Critically Dry water years (the dry water year descending limb was used because data representing Critically Dry water years were sparse). Releases during part of this period inundate lower alternate bar features, preventing germination of riparian plants on the bars. The gradual reduction of releases will also minimize the probability of stranding of fry and juvenile salmonids. During this period, releases provide at least marginal temperatures for coho salmon and chinook salmon smolts throughout most of the mainstem until late June. The gradual reduction of releases also allows gradual warming of the mainstem to provide outmigration cues to any remaining smolts.

> "Releases during part of this period [the decline from 1,500 to 450 cfs] inundate lower alternate bar features, preventing germination of riparian plants on the bars. The gradual reduction of releases will also minimize the probability of stranding of fry and juvenile salmonids."

A release of 450 cfs from June 26 through September 30 maintains suitable water temperatures for holding and spawning spring-run chinook salmon in the Trinity River above the confluence with the North Fork Trinity River.

"Instead of attempting to mimic winter floods and the associated fluvial processes during winter, these fluvial process requirements are met on a reduced scale during the snowmelt peak . . . . Recommended summer baseflows are stable and comparatively greater than those that historically occurred, but necessary to meet the thermal requirements of holding spring-run chinook salmon and spawning spring- and fall-run chinook salmon."

8.1.5 Comparison of Recommended Releases with Unregulated Hydrographs and Downstream Flows

Release schedules developed for each water-year class show the differences in recommended schedules to unregulated hydrographs at Lewiston (Figures 8.9 to 8.13). Although some components of the recommended hydrographs are similar to unregulated flows (timing of the snowmelt peak and the shape of the descending limb of the snowmelt hydrograph), other components (winter and summer flows) are dissimilar.

Frequent winter storm events, especially during Wet and Extremely Wet water years (Figures 8.9 and 8.10), were responsible for major reshaping of the pre-TRD channel morphology and maintaining the riparian community in an early seral stage, which promoted the alluvial nature of the river. Recommended releases during the winter are comparatively low to meet the microhabitat needs of spawning and rearing salmonids that must spawn and rear in the mainstem below Lewiston Dam. Instead of attempting to mimic winter floods and the associated fluvial processes during winter, these fluvial process requirements are met on a reduced scale during the snowmelt peak. This change in the timing of each year's peak flow decreases the potential of scouring redds and causing mortality of developing eggs and sac fry.

Recommended summer baseflows are stable and comparatively greater than those that historically occurred, but necessary to meet the thermal requirements of holding spring-run chinook salmon and spawning spring- and fall-run chinook salmon. As a result of construction and operation of the TRD, deep thermally stratified pools that provided summer/fall holding habitat no longer exist and releases must now be managed to provide suitable thermal regimes during this period. The lost habitats above Lewiston Dam also historically provided cool refuge because this reach of the river was largely dominated by snowmelt.

Although recommended releases for a water-year class remain the same, intra- and inter-annual flow variability will occur because of flow accretion. The unregulated flow accretion of the tributaries between Lewiston Dam (RM 111.9) and Douglas City (RM 87.7) for water years 1945 to 1951 was determined by subtracting the flow at Lewiston from the flow at Douglas City. The resulting accretion for each water year was then added to the recommended releases of the appropriate water-year class to illustrate the effect of tributary accretion below Lewiston Dam (Figures 8.14A-G). The resulting hydrographs show that substantial intra-annual flow variability will occur within the mainstem. This flow variability, especially during the late fall and winter spawning seasons, will reduce superimposition of redds by distributing spawners as flows fluctuate. Tributary accretion will also help achieve/improve some fluvial geomorphic objectives, as indicated by reduction of recommended channel-rehabilitation sites in reaches farther downstream from Lewiston Dam.

"Although recommended releases for a water year class remain the same, intra- and inter-annual flow variability will occur because of flow accretion."

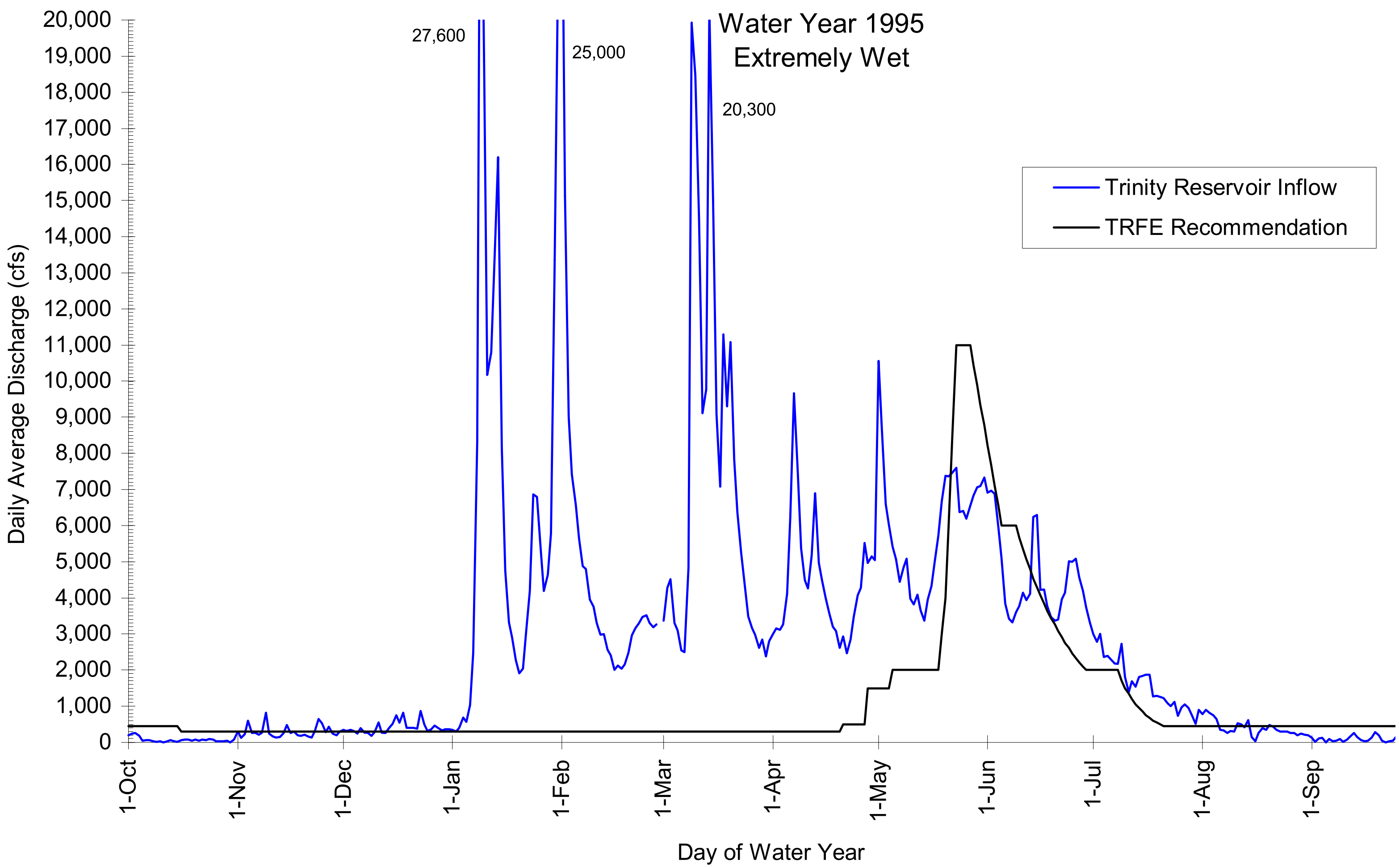

Figure 8.9. Recommended releases during an Extremely Wet water year compared to unimpaired inflow into Trinity Lake for WY 1995. Instantaneous peak discharges that exceeded the Y-axis maximum are indicated by values (cfs) placed next to the corresponding peak.

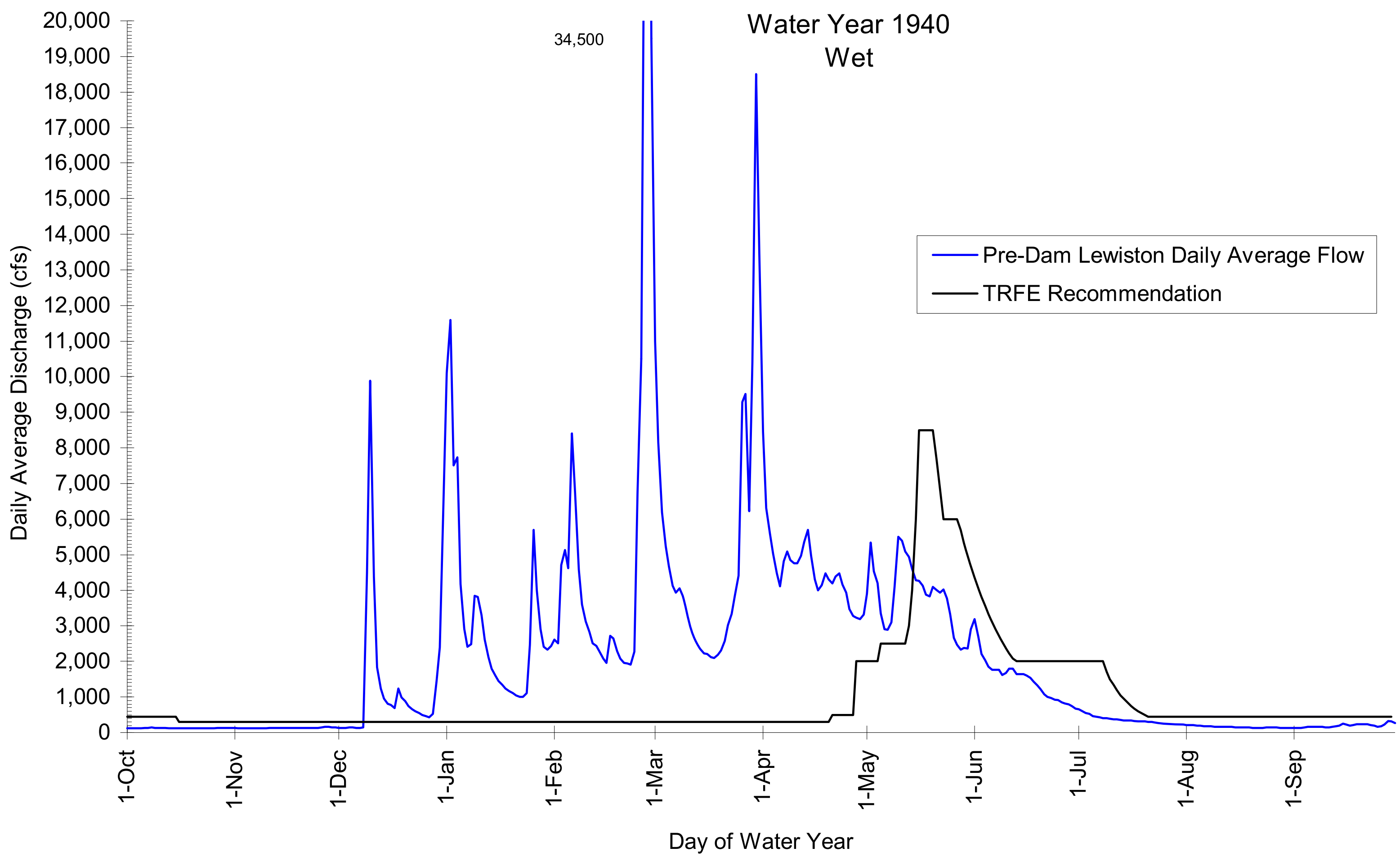

Figure 8.10. Recommended releases during a Wet water year compared to flow in WY 1940. Instantaneous peak discharges that exceeded the Y-axis maximum are indicated by values (cfs) placed next to the corresponding peak.

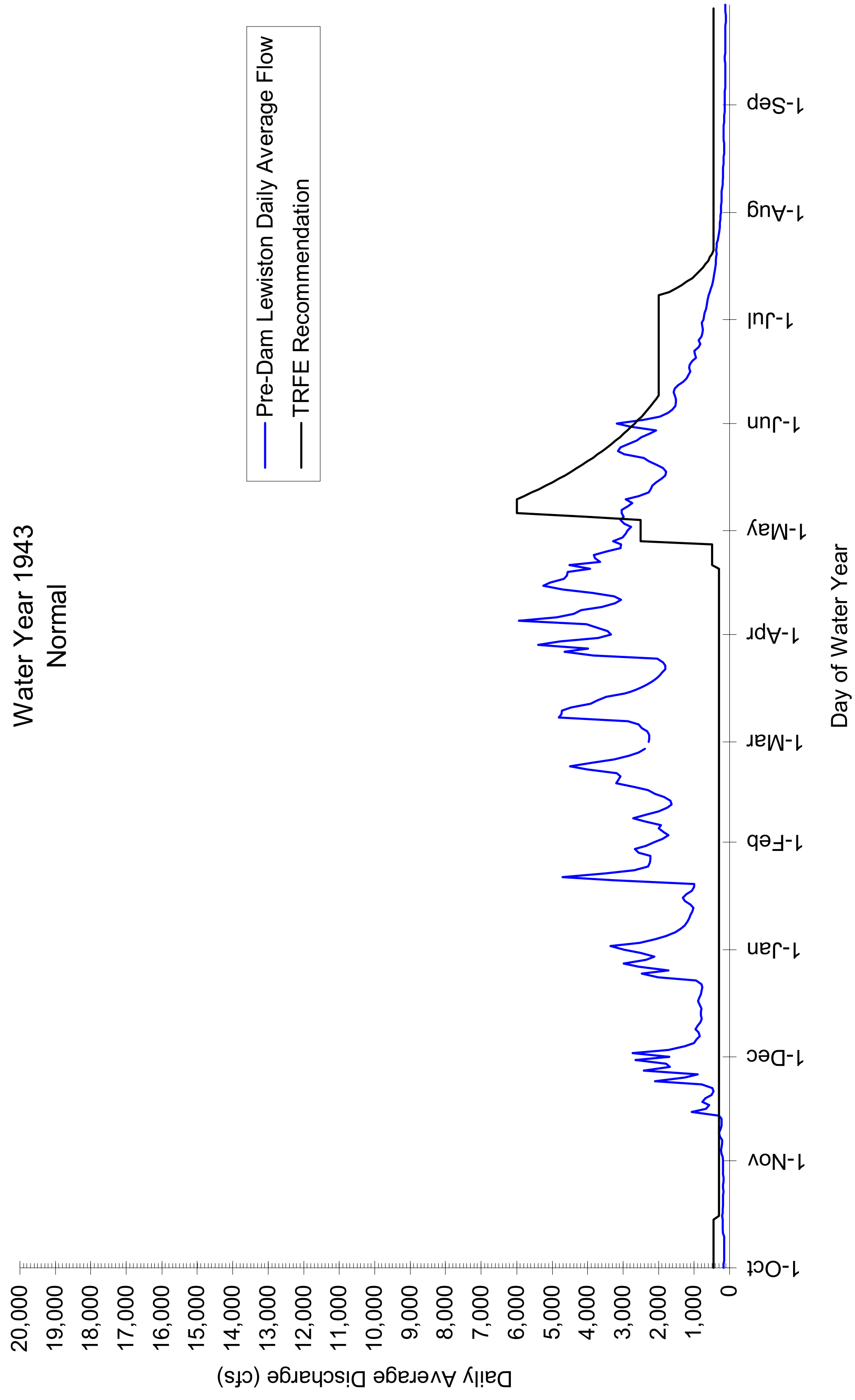

Figure 8.11. Recommended releases during a Normal water year compared to flow in WY 1943.

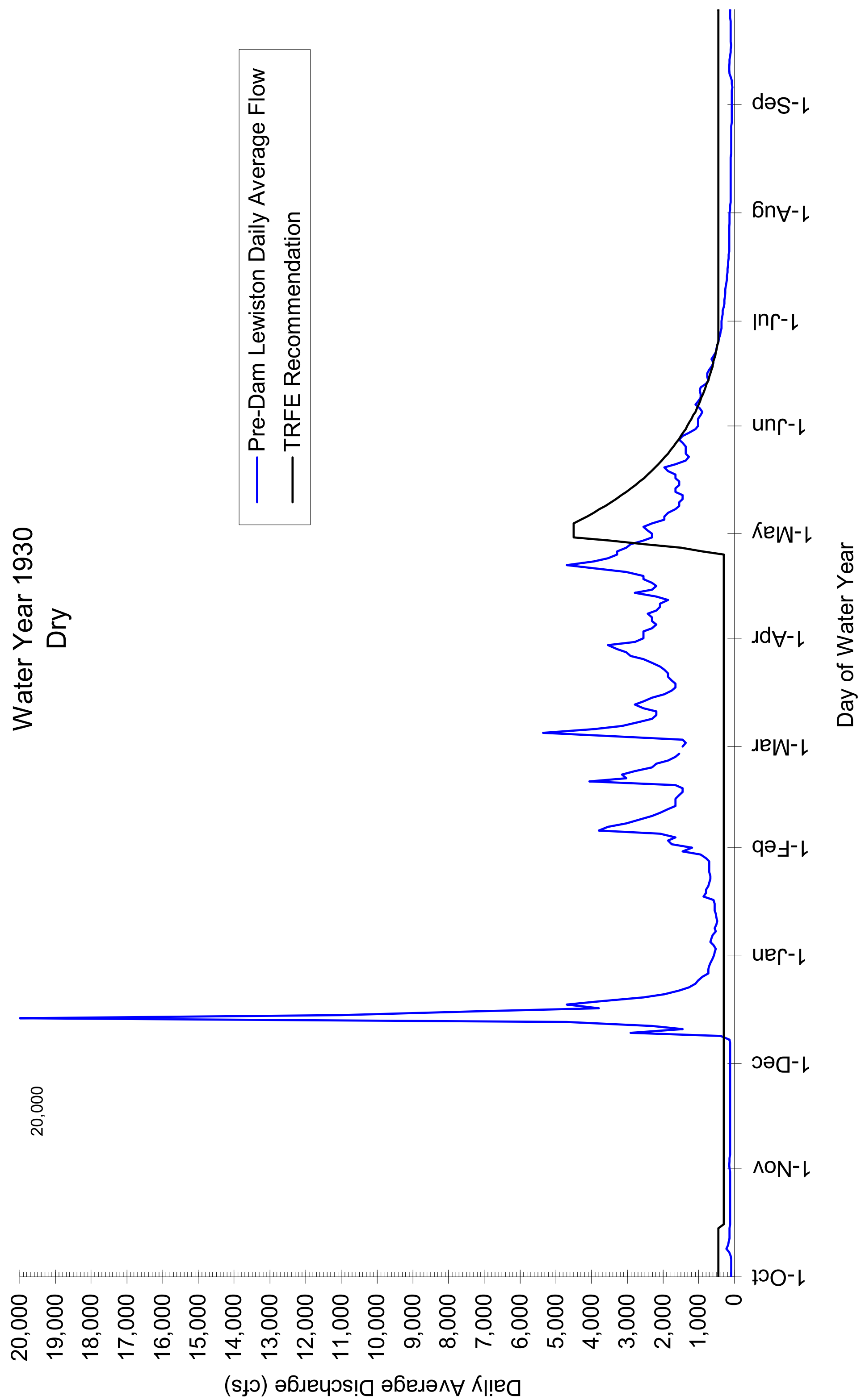

Figure 8.12. Recommended releases during a Dry water year compared to flow in WY 1930. Instantaneous peak discharges that exceeded the Y-axis maximum are indicated by values (cfs) placed next to the corresponding peak.

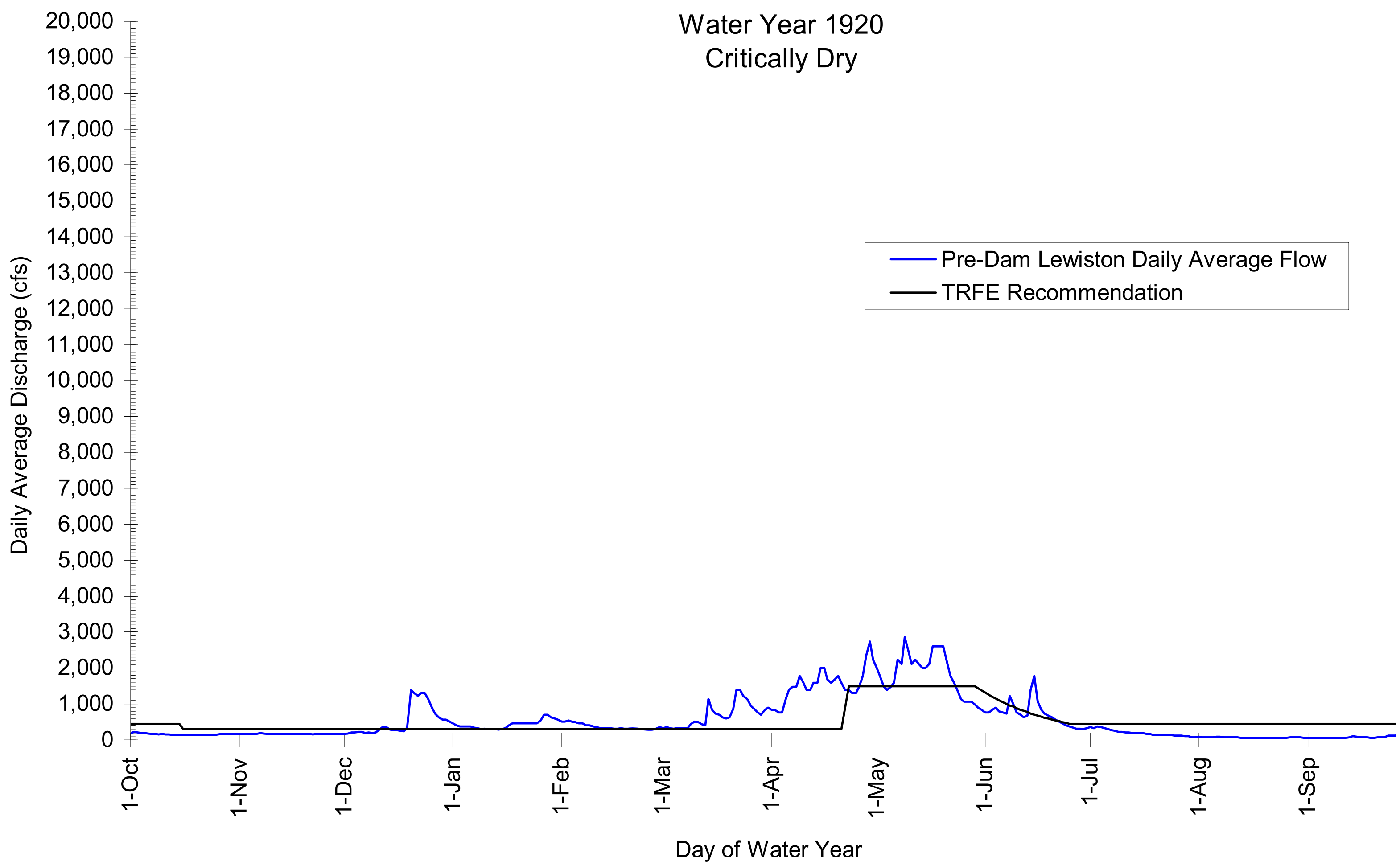

Figure 8.13. Recommended releases during a Critically Dry water year compared to flow in WY 1920.

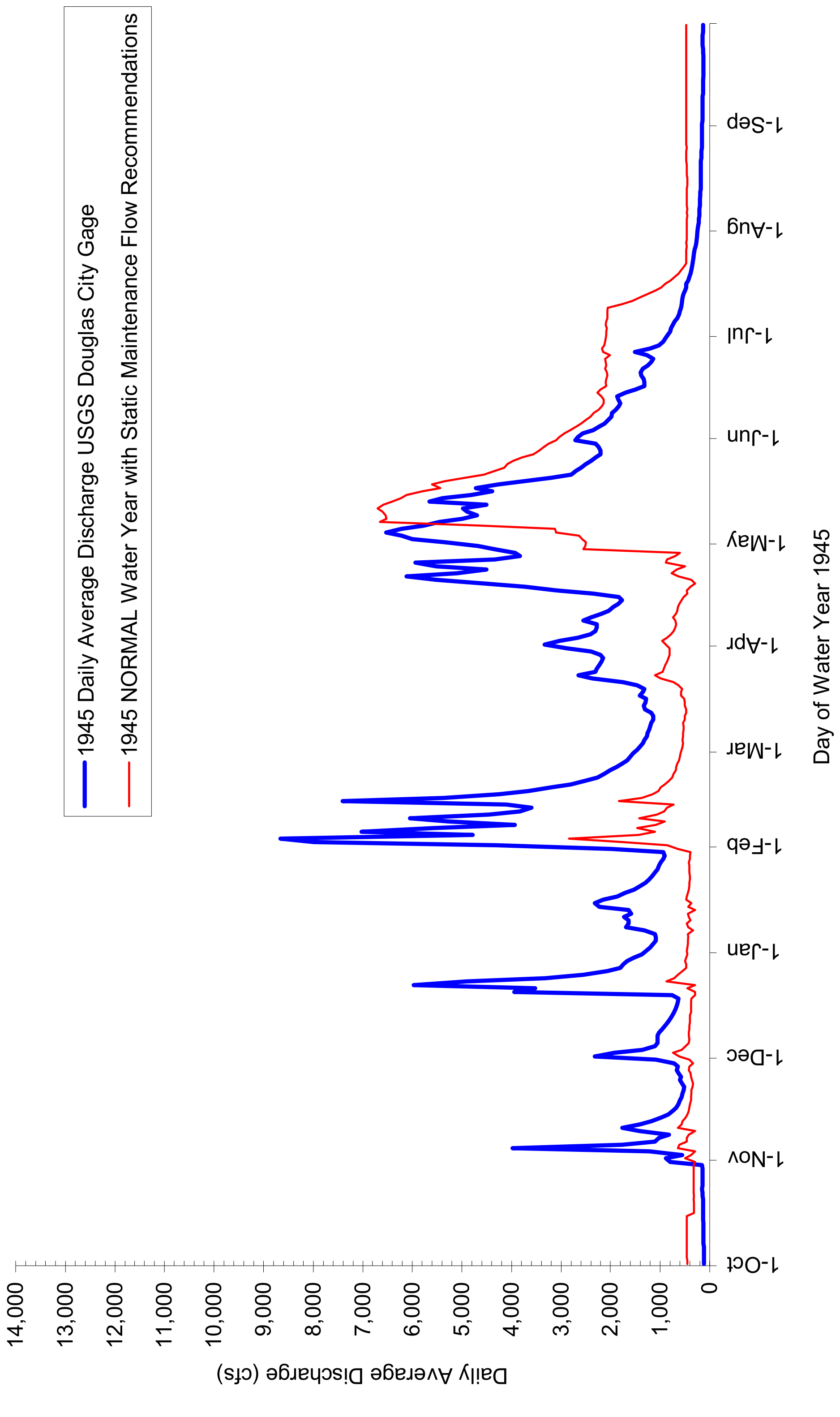

Figure 8.14a. Hypothetical discharge at Douglas City gaging station with normal water-year class release from the TRD and tributary accretion for water year 1945.

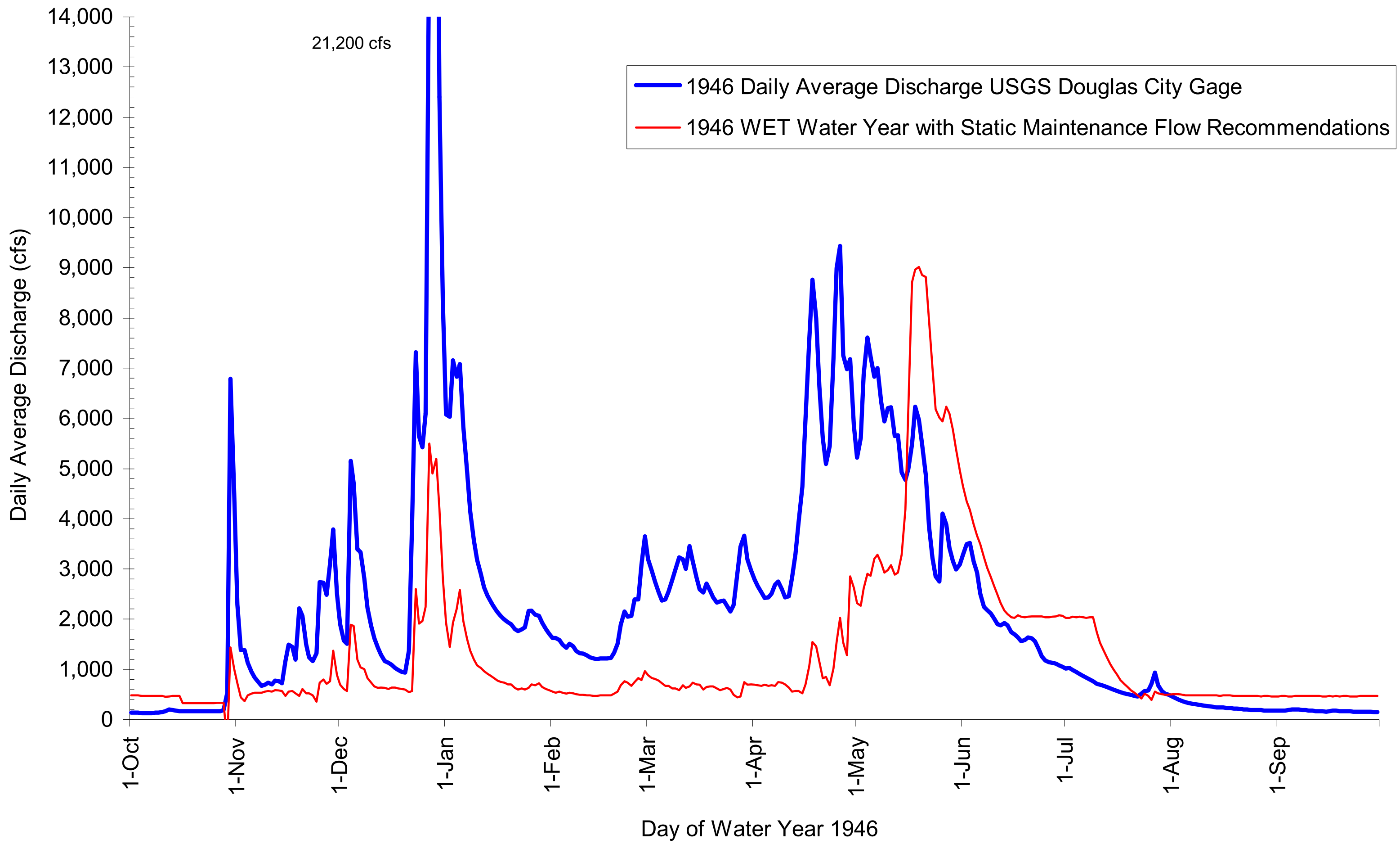

Figure 8.14b. Hypothetical discharge at Douglas City gaging station with wet water-year class release from the TRD and tributary accretion for water year 1946. Instantaneous peak discharges that exceeded the Y-axis maximum are indicated by values (cfs) placed next to the corresponding peak.

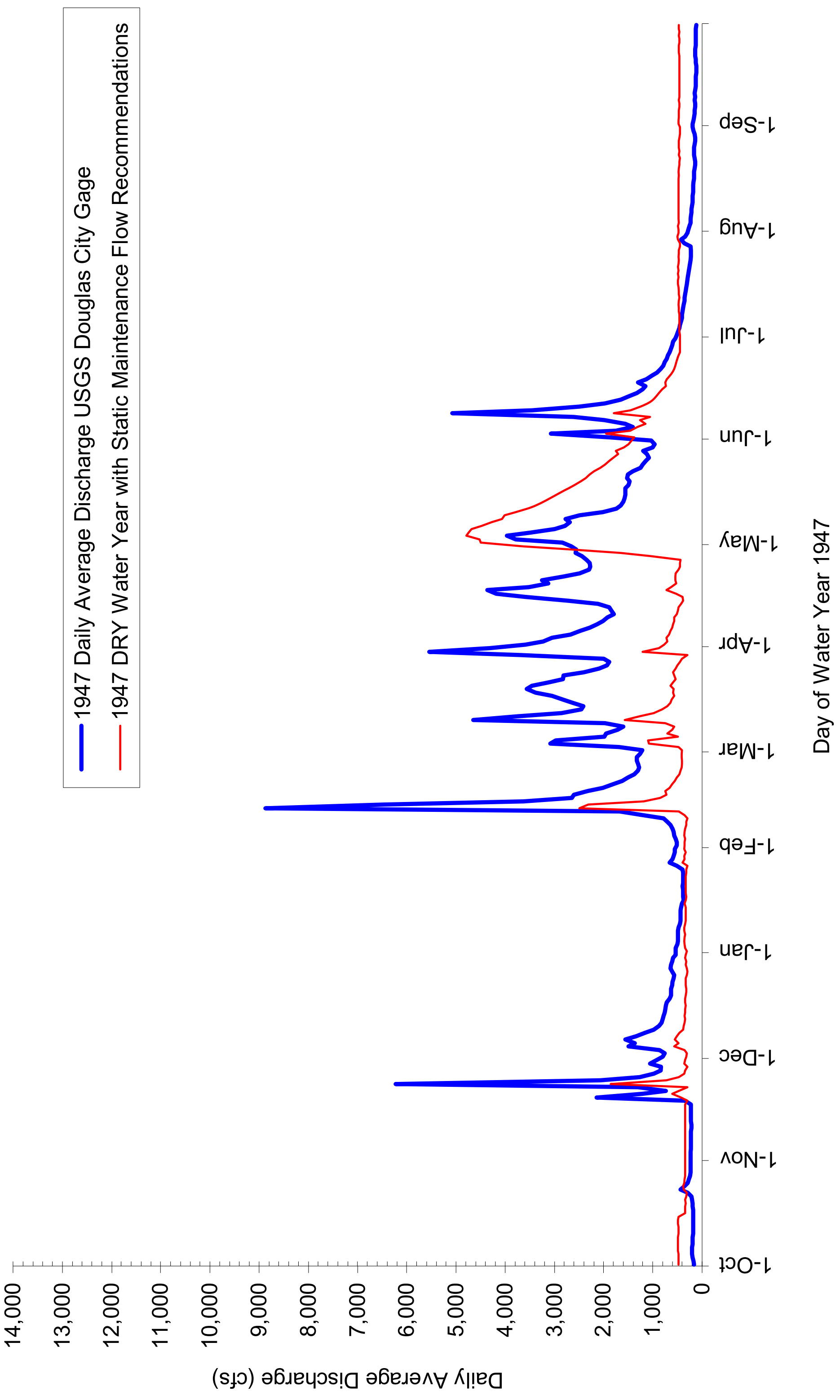

Figure 8.14c. Hypothetical discharge at Douglas City gaging station with dry water-year class release from the TRD and tributary accretion for water year 1947.

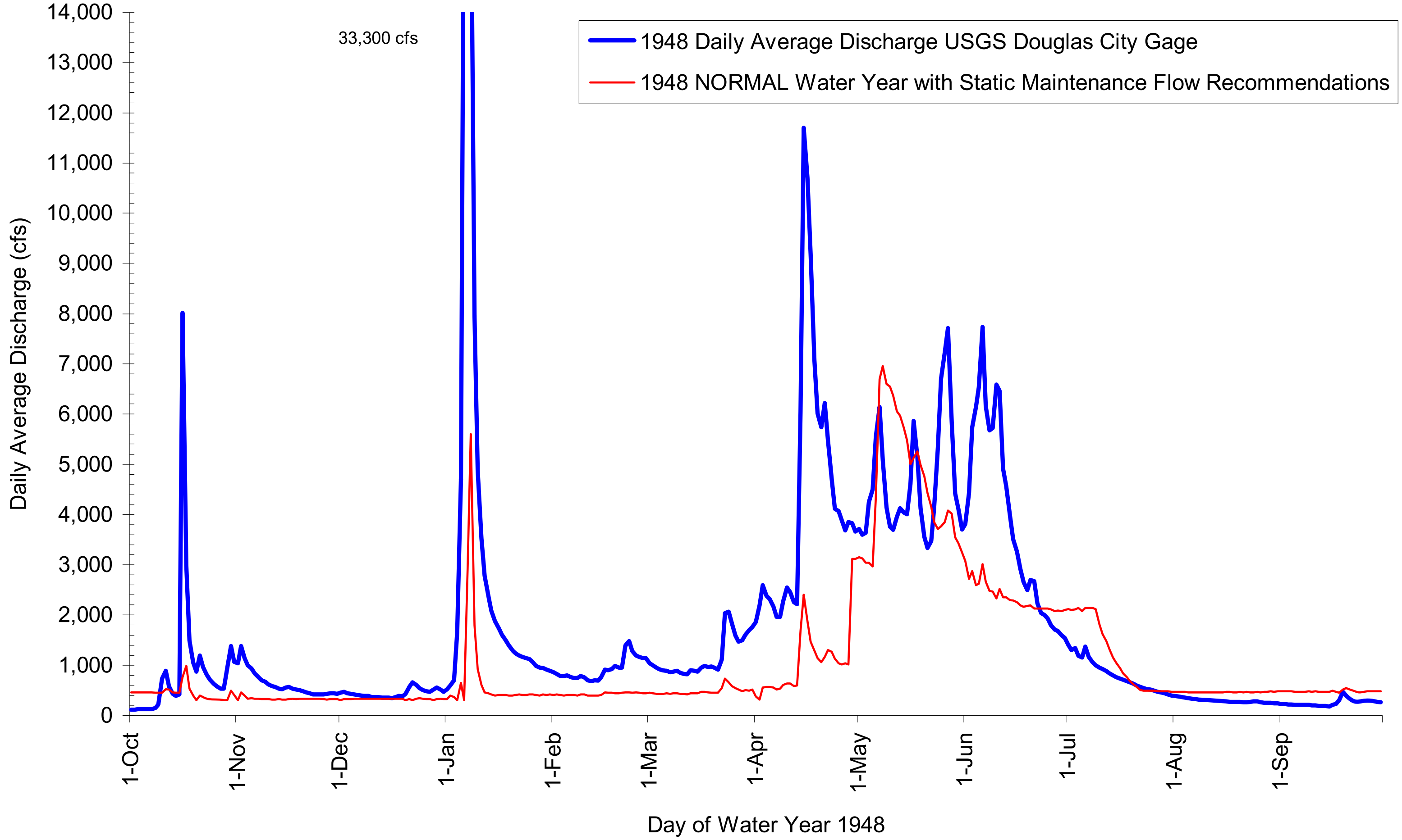

Figure 8.14d. Hypothetical discharge at Douglas City gaging station with normal water-year class release from the TRD and tributary accretion for water year 1948. Instantaneous peak discharges that exceeded the Y-axis maximum are indicated by values (cfs) placed next to the corresponding peak.

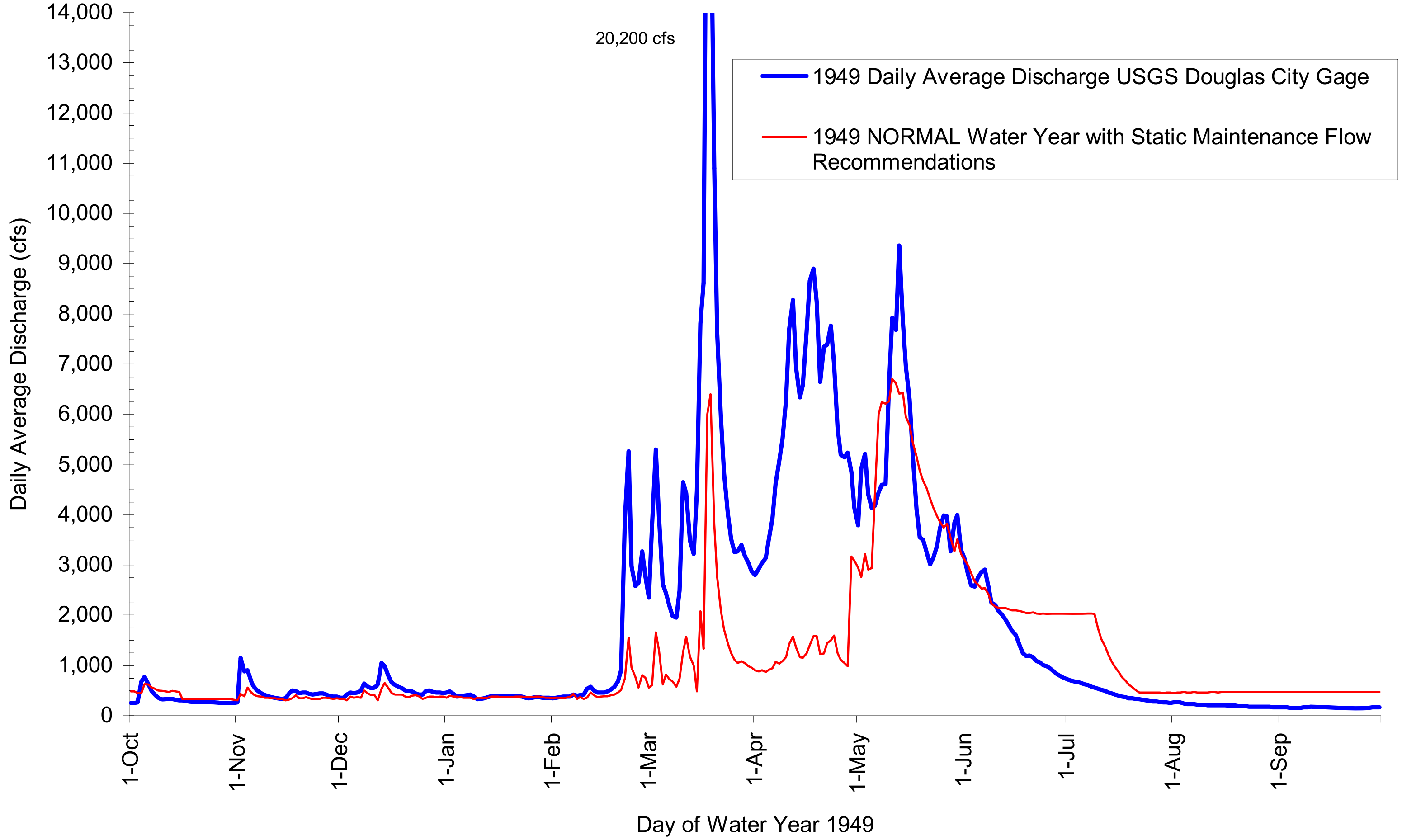

Figure 8.14e. Hypothetical discharge at Douglas City gaging station with normal water-year class release from the TRD and tributary accretion for water year 1949. Instantaneous peak discharges that exceeded the Y-axis maximum are indicated by values (cfs) placed next to the corresponding peak.

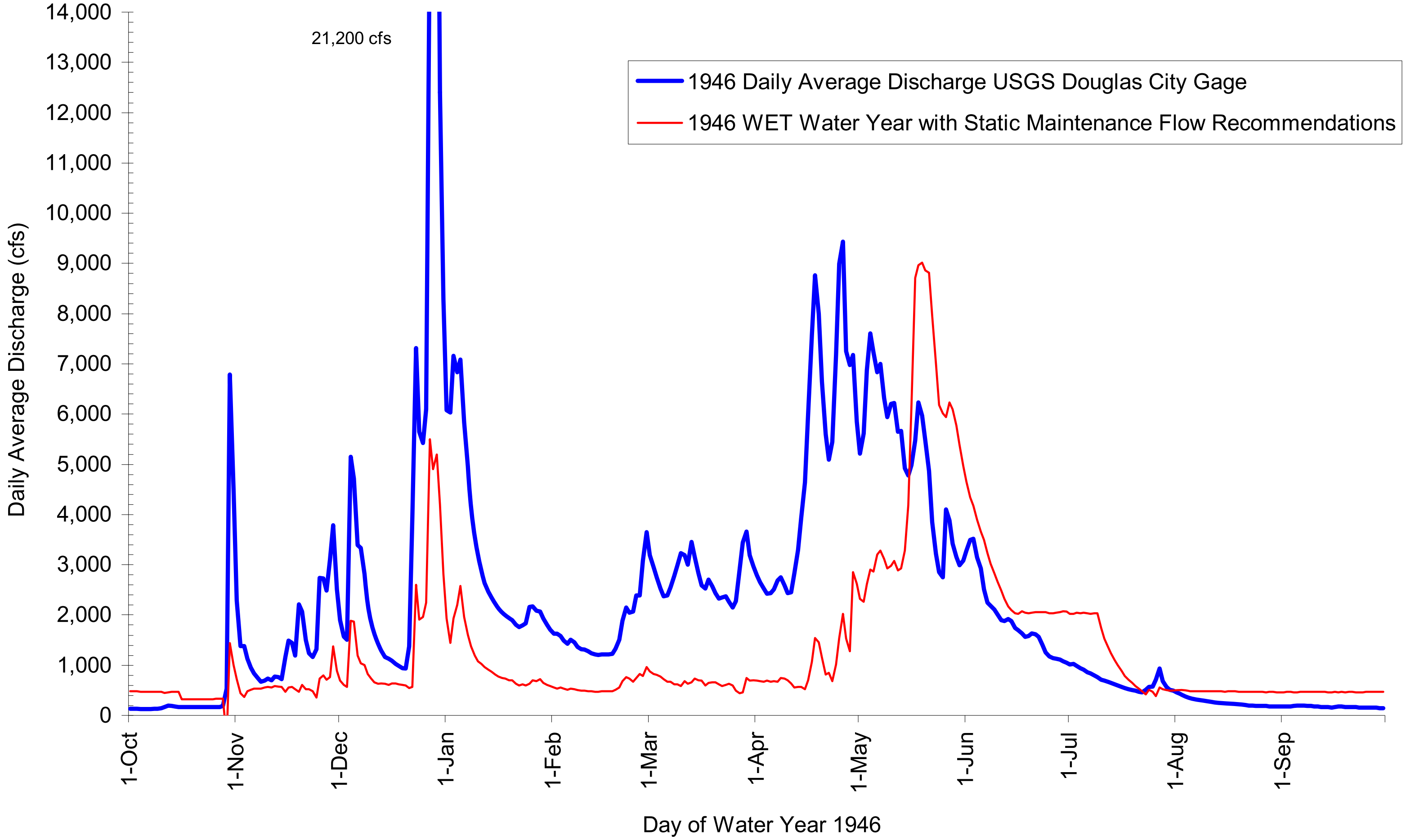

Figure 8.14f. Hypothetical discharge at Douglas City gaging station with wet water-year class release from the TRD and tributary accretion for water year 1946. Instantaneous peak discharges that exceeded the Y-axis maximum are indicated by values (cfs) placed next to the corresponding peak.

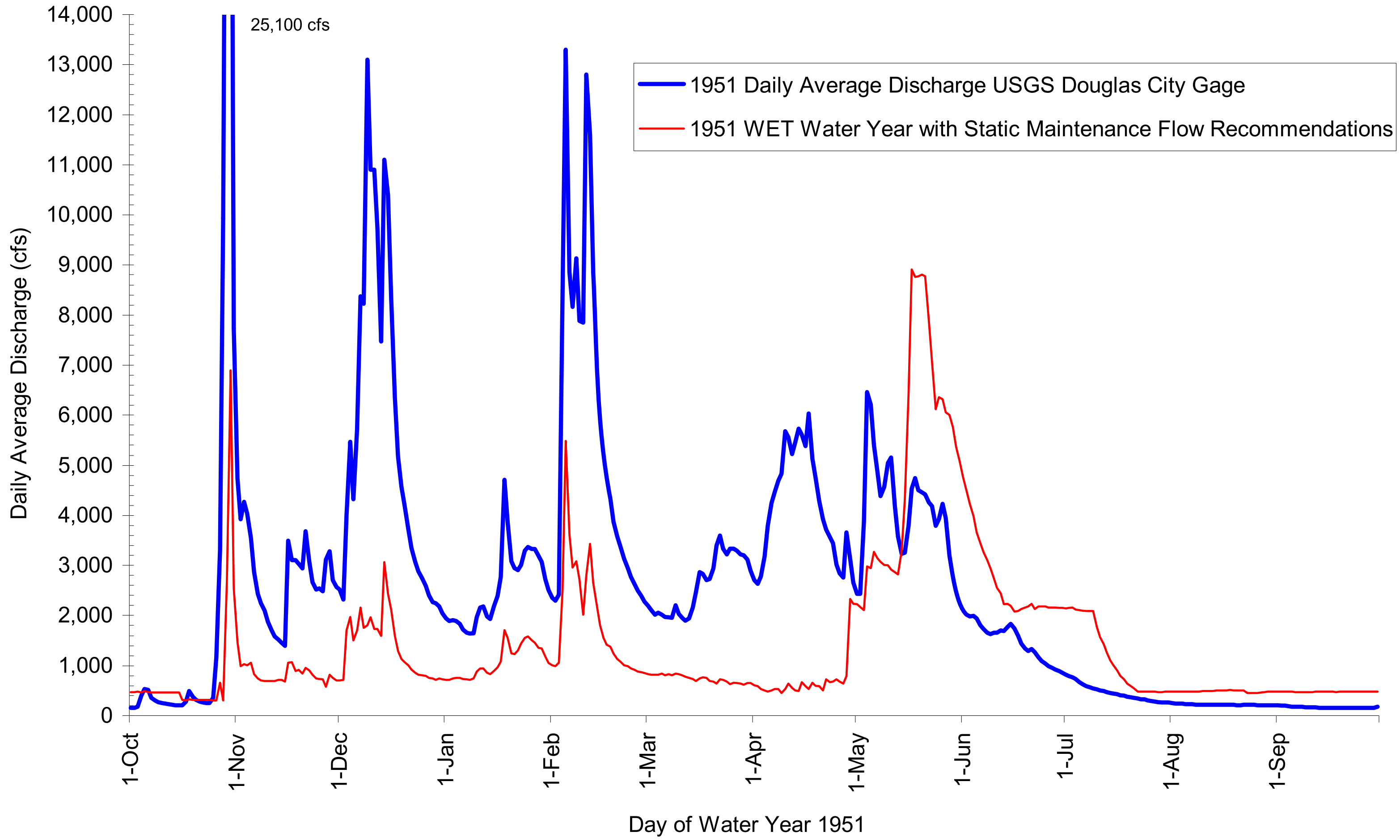

Figure 8.14g. Hypothetical discharge at Douglas City gaging station with wet water-year class release from the TRD and tributary accretion for water year 1951. Instantaneous peak discharges that exceeded the Y-axis maximum are indicated by values (cfs) placed next to the corresponding peak.

8.2 Sediment Management Recommendations

Sediment management recommendations involve four separate actions: (1) immediate placement of coarse sediment (>$^5/_{16}$ inch) to restore spawning gravels lost through mainstem transport between Lewiston Dam and Rush Creek; (2) annual supplementation of coarse sediment (>$^5/_{16}$ inch) to balance the coarse sediment budget in the Lewiston Dam to Rush Creek reach; (3) fluvial reduction of fine sediment (<$^5/_{16}$ inch) storage in the mainstem; and (4) mechanical reduction of fine sediment (<$^5/_{16}$ inch) storage in the mainstem. Additionally, recommended channel-rehabilitation projects (Section 8.3) will remove a significant amount of the fine sediment that is now stored (more than 1 million yd^3) in the riparian berms between Lewiston and the North Fork Trinity River confluence. Floodplains created as part of these projects will encourage fine sediment transported during high flows to deposit on the floodplains, thereby reducing in-channel storage.

> "High releases through 1993 to 1998 depleted spawning gravels immediately below Lewiston Dam, causing channelbed degradation . . . "

8.2.1 Short-Term Coarse Sediment Supplementation

There are two sites that require immediate coarse sediment supplementation: a 1,500 foot reach immediately downstream from Lewiston Dam (RM 111.9), and a 750 foot reach immediately upstream from the USGS cableway at Lewiston (RM 110.2) (Figure 8.15). The Lewiston Dam site last received spawning gravel supplementation in 1998. However, supplementation immediately below the Dam has not been sufficient to offset gravel transport. High releases in 1993 through 1998 caused channelbed degradation to a depth of approximately 2 feet. Restoring 2 feet of bed elevation in the Lewiston Dam reach will require approximately 10,000 yd^3 of properly graded gravel material.

The USGS cableway reach has also lost spawning gravels, degrading substantially (approximately 2 feet) over the past several years. Restoring 2 feet of bed elevation in this reach will require approximately 6,000 yd^3 of properly graded gravel material. Because the immediate benefit of gravel added to both sites will be for spawning and rearing habitat, the sizes should range from $^5/_{16}$ inch to 5 inches. The first source for gravel should be the 2,000 yd^3 of screened gravel stored at the Old Lewiston Bridge. Additional gravel may be obtained at dredge tailings downstream from Lewiston. Dredge tailings on the south bank near Lewiston (RM 108.5) and on the west bank at Gold Bar (RM 106.3) are the nearest sources. A secondary benefit realized by utilizing these dredge tailings will be the conversion of these areas to functioning floodplains with riparian vegetation.

8.2.2 Annual Coarse Sediment Introduction

Maintaining a coarse sediment balance in the reach from Lewiston Dam to Rush Creek will require annual augmentation to replace sediment transported by peak flows. Estimates of coarse sediment (>$^5/_{16}$ inch) transport during high flows for each water-year class were used to calculate replacement volumes (Table 8.10). Dredge tailings downstream from Lewiston (RM 108.5) and Gold Bar (RM 106.3) should again be used as the sediment source. Tailing materials should be screened to a size of $^5/_{16}$ to 5 inches to maximize immediate spawning benefits. Two placement methods are recommended: (1) mechanical placement in the two riffles described above in the short-term supplementation sites; and (2) insertion into the large standing wave at the Lewiston Gaging station (RM 110.9) during peak releases. Placement of gravel in the riffles should occur after annual peak releases to replace coarse bed material transported during the peak release. Coarse sediment should be

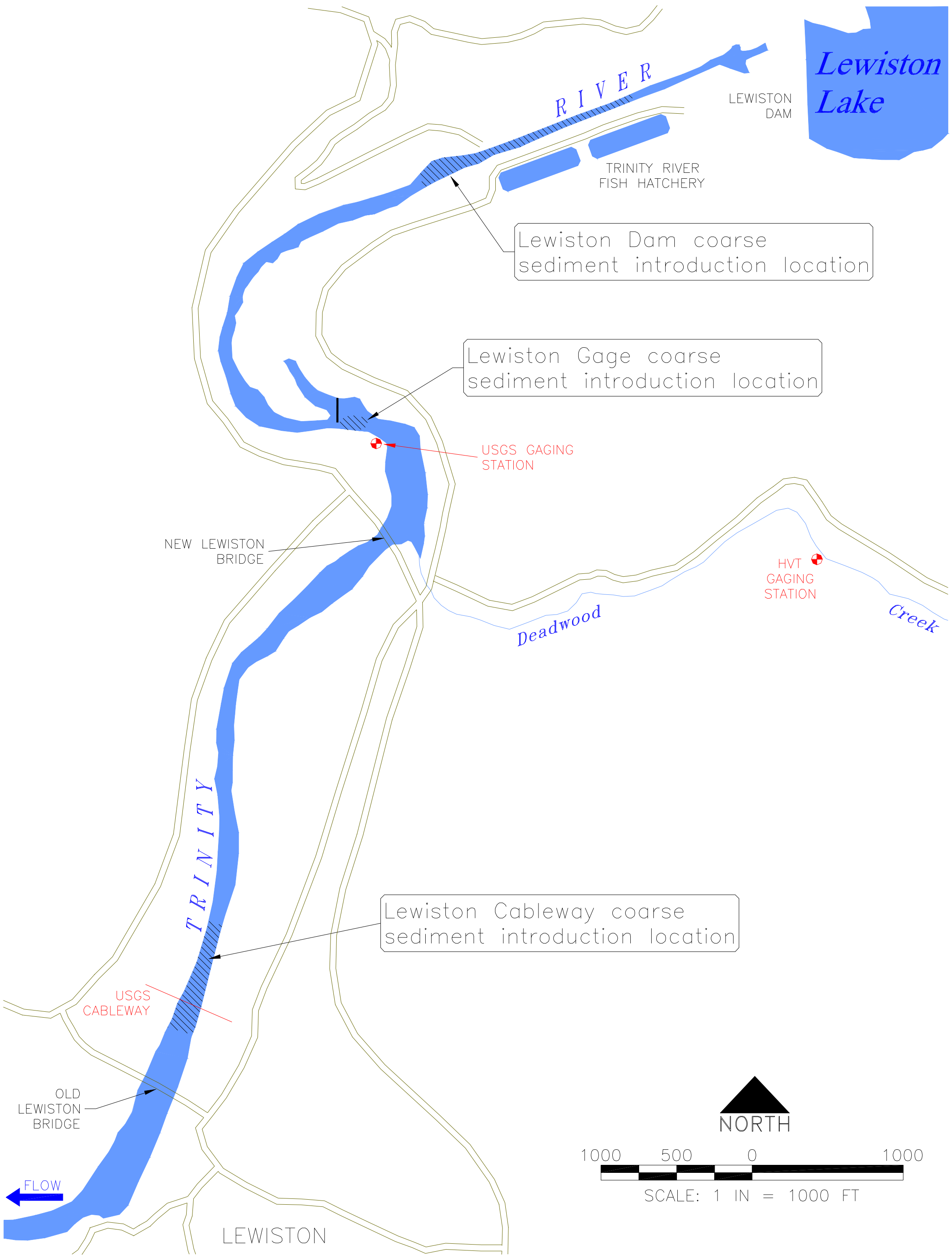

Figure 8.15. Trinity River (RM 109.8 - 111.5) priority coarse sediment supplementation locations.

Table 8.10. Annual coarse sediment replacement estimates for the Lewiston Dam to Rush Creek reach. Actual volume will be determined by modeled and measured transport each year.

Water Year	Coarse Sediment Introduction (yd^3/year)
Extremely Wet	31,000 - 67,000
Wet	10,000 - 18,000
Normal	1,800 - 2,200
Dry	150 - 250
Critically Dry	0

placed into the standing wave at the Lewiston Gaging station during peak releases to facilitate fluvial distribution downstream.

8.2.3 Fine Sediment Reduction: Sedimentation Ponds

Buckhorn Dam and Hamilton Ponds have reduced fine sediment supply from the Grass Valley Creek watershed. Their operation and maintenance should be continued. A fundamental problem, however, has been rapid filling of Hamilton Ponds during high-flow events, and subsequent reduced trapping efficiency, allowing fine sediment to transport into the Trinity River. Funding and a sediment removal contract needs to be continually in place so that sediment deposited in the ponds can be removed during the storm season to maintain trapping efficiency. Most sediment trapped by the Hamilton Ponds is sand; however, the coarse sediment (>$^5/_{16}$ inch) should be screened from deposits and returned to the Trinity River at the mouth of Grass Valley Creek to help maintain adequate coarse sediment supply downstream and reduce the volume of spoils removed from Hamilton Ponds.

Hoadley Gulch (RM 109.8) is a small tributary entering the Trinity River 2 miles downstream from Lewiston Dam that contributes substantial quantities of sand to the Trinity River during large storm events. The volume of sand yielded to the Trinity River from Hoadley Gulch has not been quantified; therefore, no comparison of volume can be made with the sediment-transport capacity of the Trinity River. The relative importance of Hoadley Gulch's sand contribution in comparison with other tributaries (e.g., Rush Creek) should be evaluated to determine if a sedimentation pond is warranted.

8.2.4 Fine Sediment Reduction: Pool Dredging

Measurements and observations in pools downstream from Grass Valley Creek show that fine sediment storage is decreasing. Recommended flow regimes should further decrease in-channel fine sediment storage. Therefore, pool dredging is not recommended, but may be considered under the adaptive environmental assessment and management program (see Section 8.4).

"Funding and a sediment removal contract needs to be continually in place so that sediment deposited in the ponds can be removed during the storm season to maintain trapping efficiency."

8.3 Channel Rehabilitation

Channel-rehabilitation recommendations fall into four categories:

1. Bank rehabilitation on a forced-meander bend (Figure 8.16);

2. Alternate bar rehabilitation over longer reaches (Figure 8.17);

3. Side channel construction over short reaches (Figure 8.18); and

4. Tributary delta maintenance. Local removal of the very coarse sediment (boulders) that causes aggradation and hydraulic backwater effects upstream from deltas.

The Service and Hoopa Valley Tribe identified 44 potential channel-rehabilitation sites (Appendix G, Plate 1), 3 potential side channel-rehabilitation sites (Appendix G, Plate 2), and 2 tributary delta maintenance sites in the reach between Lewiston Dam and the North Fork Trinity River. These sites are located where channel morphology, sediment supply, and high-flow hydraulics would encourage a dynamic, alluvial channel (Table 8.11). A short implementation period for a significant number of these projects and an evaluation of whether they achieve their intended benefits is recommended. Those benefits— increasing quality and quantity of salmonid habitat— need to be balanced by logistics, contractor availability, and construction windows. Therefore, construction of 24 of the 44 channel-rehabilitation sites in the first 3 years is recommended. The remaining projects may proceed following a re-evaluation by the Adaptive Environmental Assessment Management Program (see Section 8.4).

"These [channel rehabilitation] sites are located where channel morphology, sediment supply, and high-flow hydraulics would encourage a dynamic, alluvial channel."

The Lewiston Dam to Rush Creek and Rush Creek to Indian Creek reaches are distinctly different from those downstream owing to the considerable accretion of flows and sediment downstream from Indian Creek. As a result, unique strategies are recommended for each reach:

Lewiston Dam to Rush Creek (RM 111.9 to RM 107.5)

- Construct bank rehabilitation and alternate bar rehabilitation projects that include building skeletal point bars after riparian berms are removed to encourage development of alternate bars and increase coarse sediment supply in the reach. Skeletal bars would have a framework of large cobbles (> 5 inches), covered by several feet of finer material ($^5/_{16}$ to 5 inches).

- Revegetate reconstructed floodplains with native woody riparian species, emphasizing black cottonwood (*Populus balsamifera*) and Fremont cottonwood (*Populus fremontia*) to increase the seed source for natural regeneration.

- Maintain existing side channels. Because coarse sediment supply is less than in downstream reaches, plugging by sediment deposition is less likely than for side channels downstream from Indian Creek.

- Remove the coarse fraction (boulders) of Rush Creek delta deposit to lessen backwater effect and improve sediment-routing from upstream reach.

- Construct three bank rehabilitation projects and two alternate bar rehabilitation projects during years 1-3 to increase habitat in this important spawning and rearing reach. Rebuild floodplains and point bars to initiate channel migration, allow floodplain inundation, and encourage natural side channel and backwater creation.

Rush Creek to Indian Creek (RM 107.5 to RM 95.3)

- Construct bank rehabilitation and alternate bar rehabilitation projects that include building

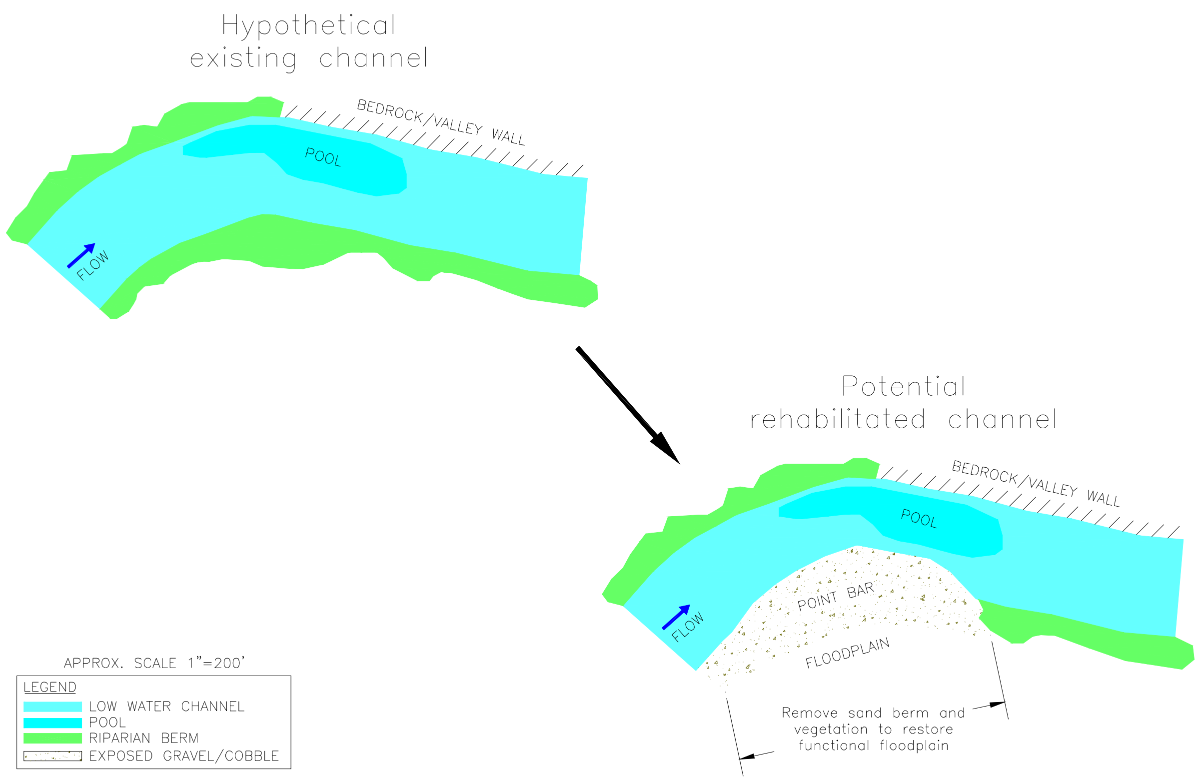

Figure 8.16. Trinity River conceptual single forced meander channel rehabilitations.

skeletal point bars after riparian berms are removed to encourage development of alternate bars and increase coarse sediment supply in the reach. Skeletal bars would have a framework of large cobbles (>5 inches), covered by several feet of finer material ($^5/_{16}$ to 5 inches).

- Revegetate reconstructed floodplains with native woody riparian species, emphasizing black cottonwood (*Populus balsamifera*) and Fremont cottonwood (*Populus fremontia*) to increase the seed source for natural regeneration.

- Maintain existing side channels. Because coarse sediment supply is less than in downstream reaches, plugging by sediment deposition is less likely than for side channels downstream from Indian Creek.

- Evaluate high-flow hydraulics of the two potential side channel sites, and construct these only if potential for self-maintenance is high.

- Remove the coarse fraction (boulders) of Indian Creek delta deposits to lessen the backwater effect and improve sediment-routing from upstream reach.

- Construct 7 of the 14 bank and alternate bar rehabilitation projects in years 1-3. Rebuild floodplains and point bars to initiate channel migration, allow floodplain inundation, and encourage natural side channel and backwater creation.

Indian Creek to Dutch Creek (RM 95.3 to RM 86.3)

- Because coarse sediment supply and tributary flood events are increasing downstream from Indian Creek, construction of skeletal point bars may not be required. Simply removing the riparian berm at key

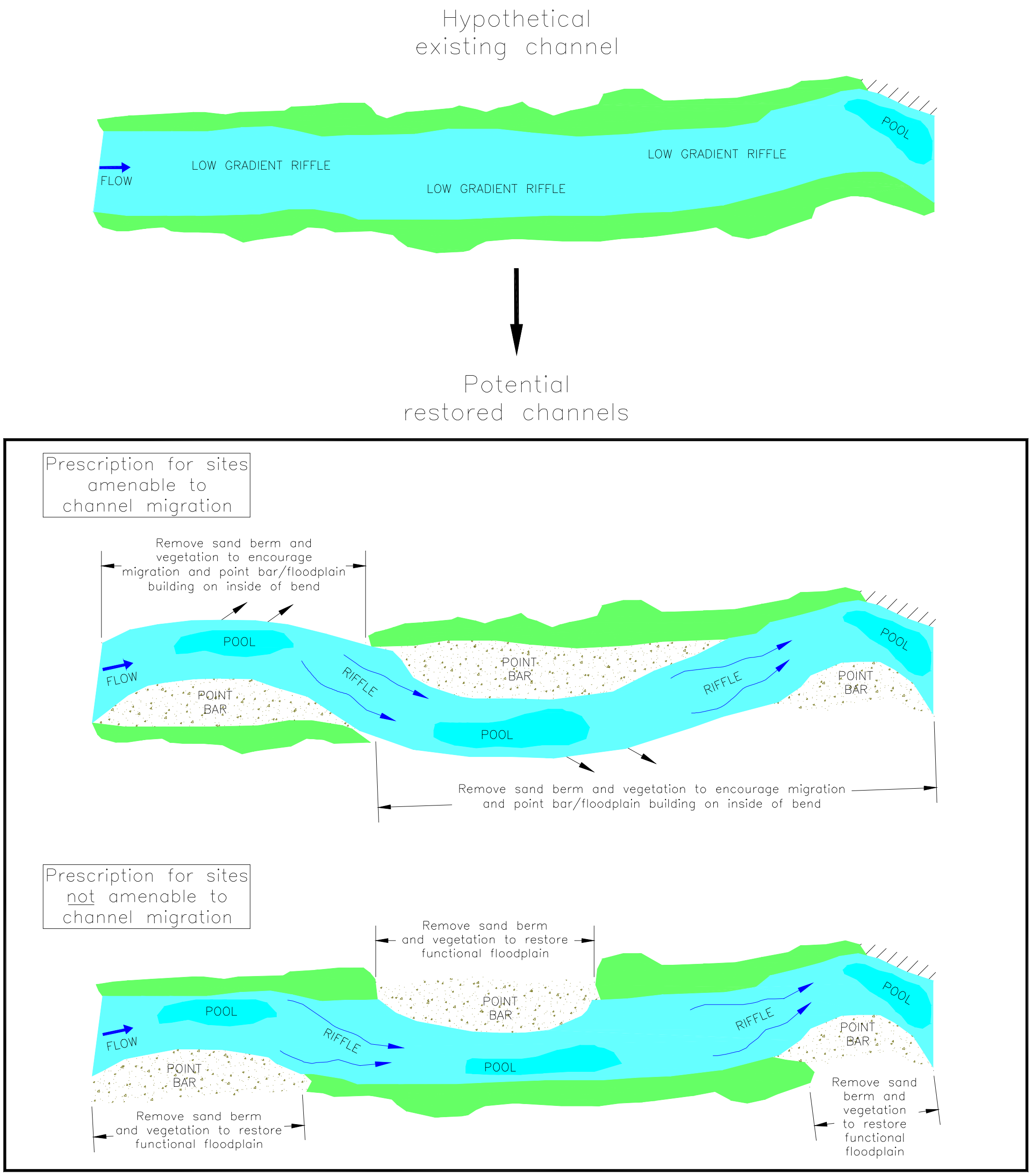

Figure 8.17. Trinity River conceptual alternate bar channel rehabilitation.

locations may induce alternate bars to form during high flows. If bar formation does not occur following first years of high flows, construction of skeletal bars (described above) should be considered in subsequent years.

- Construct five of the seven bank and alternate bar rehabilitation projects in years 1-3. Rebuild floodplains and point bars to initiate channel migration, allow floodplain inundation, and encourage natural side channel and backwater creation.

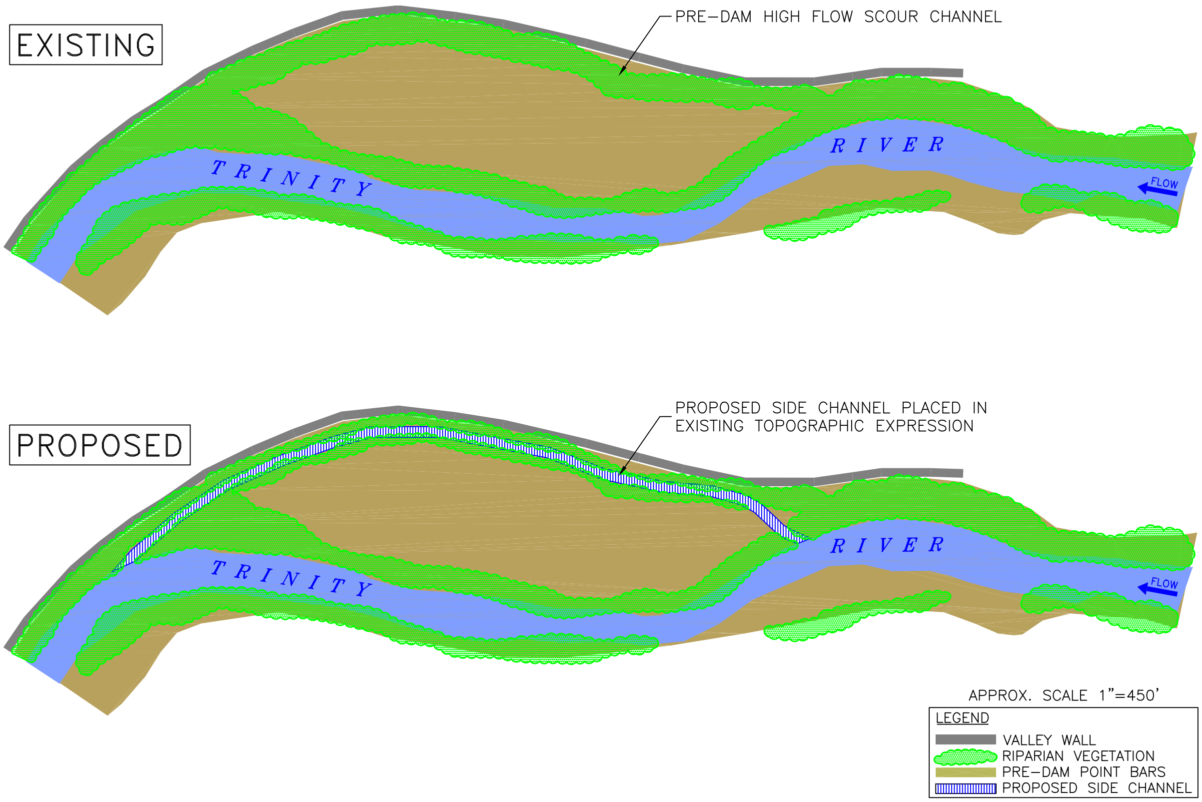

Figure 8.18. Trinity River conceptual side channel rehabilitation.

- Revegetate reconstructed floodplains with native woody riparian species, emphasizing black cotton-wood (*Populus balsamifera*) and Fremont cottonwood (*Populus fremontia*) to increase the seed source for natural regeneration.
- Evaluate high-flow hydraulics of side channel site, and construct only if potential for self-maintenance is high.
- Evaluate whether constructed side channels should be abandoned. Because this mainstem segment is considerably more dynamic than upstream segments, maintenance of side channels will be costly.

Dutch Creek to North Fork (RM 86.3 to RM 72.4)

- Bank and alternate bar rehabilitation projects in this reach are not likely to require skeletal bars to be constructed, because coarse sediment supply and flow accretions increase substantially downstream from Indian Creek. Simply removing the riparian berm at key locations will likely induce alternate bars to form during subsequent high flows. If bar formation does not occur following initial high flows, construction of skeletal bars (described above) should be considered in subsequent years.
- Construct 7 of the 18 bank and alternate bar rehabilitation projects in years 1-3. Rebuild flood-plains and point bars to initiate channel migration, allow floodplain inundation, and encourage natural side channel and backwater creation.

Table 8.11. Potential channel-rehabilitation sites between Lewiston Dam and the North Fork Trinity River.

Reach	River Mile	Potential bank rehabilitation sites	Potential alternate bar rehabilitation sites	Potential side-channel sites
Lewiston Dam to Rush Creek	111.9 - 107.5	3	2	0
Rush Creek to Indian Creek	107.5 - 95.3	7	7	2
Indian Creek to Dutch Creek	95.3 - 86.3	3	4	1
Dutch Creek to North Fork Trinity River	86.3 - 72.4	10	8	0
Total		23	21	3

- Evaluate high-flow hydraulics of potential side channel site, and construct only if potential for self-maintenance is high.
- Channel-rehabilitation projects should be larger in this reach than in upstream reaches because of increasing channel size and channel-forming flows. Reshaping floodplain areas and low terraces, especially in areas adjacent to dredge tailings, will be required.
- Revegetate reconstructed floodplains with native woody riparian species, emphasizing black cottonwood (*Populus balsamifera*) and Fremont cottonwood (*Populus fremontia*) to increase the seed source for natural regeneration.
- Abandon constructed side channels and incorporate these areas into floodplains.
- Incorporate constructing off-channel wetlands and oxbow ponds into rehabilitation projects, specifically in projects with adjacent dredge tailings.

8.4 AEAM Recommendations to Monitor and Refine the Annual Operating Criteria and Procedures (OCAP) and Other Recommendations for Restoring and Maintaining the Trinity River Fishery Resources

This Trinity River Flow Evaluation Report concludes that the river channel has degraded to such an extent that simply managing flow releases from the existing reservoirs cannot achieve the salmonid restoration goals mandated by Congress. The primary hypothesis is that a combination of managed high-flow releases, mechanical riparian berm removal, and gravel augmentation will redirect geomorphic processes so that a more complex channel form will evolve, creating the mosaic of aquatic habitats necessary to enhance freshwater salmonid production. Although many of the anticipated changes will be monitored on an annual or semiannual basis, longer-term monitoring and assessment must also occur concurrently due to the prolonged life-histories of salmonids. Over a longer time period, adult returns and the numbers of fish contributing to ocean and inriver fisheries will be a measure of success.

> This Trinity River Flow Evaluation Report concludes that the river channel has degraded to such an extent that simply managing flow releases from the existing reservoirs cannot achieve the salmonid restoration goals mandated by Congress.

Reservoir releases and channel-rehabilitation projects should substantially increase carrying capacity (usable salmonid rearing habitat area) within the rehabilitated channel. What is not known is the rate of change or time frame needed to achieve this new channel equilibrium. AEAM (Appendix N) will facilitate achieving the salmonid restoration goals. The management actions prescribed include channel rehabilitation in combination with annual reservoir releases based on forecasted water supply and the recommended flow regime for the water-year class based on the hydrographs presented in this chapter. These water year flow regimes, each with unique hydrograph components, provide the inter-annual variability necessary to drive the fluvial processes toward a new channel configuration while maintaining the hydraulic and temperature conditions at levels that are greater in quality than those existing since the closure of the dams.

8.4.1 Goals and Objectives for the Trinity River

One of the stated goals for the Trinity River is " . . . the development of recommendations regarding permanent instream fishery flow requirements and Trinity River Division operating criteria and procedures for restoration and maintenance of the Trinity River fishery" (Central Valley Project Improvement Act, Title XXXIV of P.L. 102-575). This report recommends five flow regimes (Appendix M), including operating criteria and procedures for each water-year class. Primary objectives of the recommendations are:

1. Manage the reservoir releases to provide a much improved (near optimum) temperature regime. An optimum temperature regime increases fish residence time and growth rates, resulting in larger smolts exiting the system. Larger smolts have better survival leading to an increase in number of returning adults.

2. Manage the river corridor to increase the shallow-edgewater and backwater habitats necessary for many anadromous young-of-year salmonids.

3. Manage reservoir releases to control vegetation establishment on alluvial features. Schedule reservoir releases to scour seedlings on bars following the seed fall during the spring-summer period. Investigate superimposing reservoir releases on tributary flows when the opportunity is present.

4. Manage reservoir releases within the evolving channel to optimize hydraulic conditions for spawning, incubation, and young-of-year production for a given water year and channel form. As the channel changes from the present trapezoidal form toward the desired alternating point bar configuration, the slope of the hydrograph should be adjusted annually to maximize suitable conditions for a given year.

8.4.2 Hypotheses

The premise of the Trinity River Flow Evaluation Report recommendations is that a combination of mechanical alterations and vegetation removal in addition to

> The primary hypothesis of this flow evaluation is that a combination of managed high-flow releases, mechanical riparian berm removal, and gravel augmentation will redirect geomorphic processes so that a more complex channel form will evolve, creating the mosaic of aquatic habitats necessary to enhance freshwater salmonid production.

managed high-flow releases in the spring will promote geofluvial processes leading to a new channel form that is expected to provide significantly increased spawning and rearing habitat for anadromous salmonids. The assumptions, hypotheses, and logic upon which the recommended management actions presented in this report are based are summarized in Appendix O. Only the most prominent hypotheses are presented.

One of the central hypotheses is that habitat diversity in the upper river, both on the meso- and micro-habitat scale, will increase following the implementation of the recommendations. Although the changes in habitat diversity are expected to be obvious, there will remain a question as to degree of change. A methodology must be embraced to quantify the existing habitat diversity and the annual change created as the management recommendations are implemented. This will enable comparative evaluations to be made and elucidate the effectiveness of specific restoration measures.

A second hypothesis central to the recommendations is that juvenile salmonid rearing habitat, believed to be limiting smolt production in the Trinity River, will increase in both quantity and quality following the creation of a more complex and dynamic channel form. Rearing habitat area, which at present is highly variable depending on streamflow, will increase (at least a doubling) and become more stable over a wide range of flows.

The third central hypothesis is that salmonid smolt survival will improve as a result of better temperature conditions that increase growth and promote extended smoltification and reduced travel time associated with emigration.

Before proceeding with AEAM, this set of hypotheses and series of events is transformed into a set of measurable responses. By way of examples, we offer three initial quantification steps.

First, describe the existing channel geometry in two dimensions by sub-sampling along surveyed transects or grids. Sub-sampling should be sufficient to describe the bathymetry of the alternate bar pool sequences at upper, lower and middle portions of the river from Lewiston Dam to the North Fork Trinity River confluence. Transects should be geo-referenced so that monitoring measurements can be repeated. These measurements are needed to quantify the degree of bar formation, lateral movement, and establishment of woody vegetation attained on an annual basis. The straight trapezoidal channel should evolve toward a more sinuous alternate bar form having increased shallow water area and low-velocity backwaters critical for rearing young salmonids.

Second, the amount of habitat area available to provide suitable spawning and rearing conditions should be measured annually. Geomorphology, vegetation conditions, and salmonid habitat must be quantified using the same sampling strategy. The same strategy allows extrapolation describing 40 miles between Lewiston Dam and the North Fork Trinity River confluence.

Third, the length and weight of chinook salmon young-of-year can be sampled every few weeks from hatching through emigration from the stream study segment. Substantial trapping effort at the downstream end of the study segment is needed to estimate the total number of chinook salmon pre-smolts leaving the segment. These two sets of measurements can be used to estimate growth increments through the season and young-of-year production within the river. In addition to the hypotheses and water year rehabilitation objectives, the state of the knowledge is presented in Appendix O as a solid science foundation for the AEAMP to build upon.

8.4.3 Document Channel Form, Riparian Vegetation, and Salmonid Population Trends

Through comparison of annual measurements and the use of simulation modeling, progress toward the habitat and production objectives can be quantitatively expressed. Progress toward the program objectives and any trends identified should be reported annually to the stakeholders. This report may address the following questions:

Are salmonid population numbers (quantify as population estimates not just abundance indices) improving?

Is anadromous salmonid habitat improving?

Are native riparian communities establishing on different geomorphic surfaces? Are reservoir releases removing germinated vegetation?

Are the riparian berms continuing to build, are they remaining stable, or are they beginning to break down from Lewiston Dam to the North Fork Trinity River confluence?

Are channel reaches migrating laterally and becoming more dynamic?

Are floodplains forming?

Are alternate bars forming?

How does Trinity River water affect water quality of the Klamath River? There is evidence that water-quality conditions in the Klamath River may be, at times,

Causal Analysis – A Complement to Time Series

Monitoring often produces a time-series representation of the changes in a system. However, time is rarely the cause of the changes. AEAM focuses on causal analysis of monitoring data. Ordinarily the object of the monitoring occupies the x-axis, and is plotted against time (y-axis). While indicative of the trends in a system, time-series fail to directly expose the causes of the more obvious trends. Causal analysis replaces time on the abscissa with causative factors (e.g., habitat). A strong functional relationship indicates causation of trends in the system. The figures demonstrate the difference between a time-series and a causal analysis.

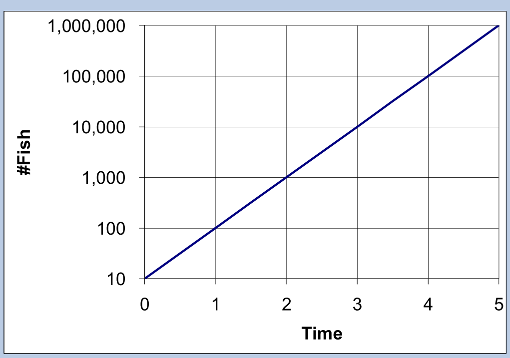

Figure 1. Time Series.

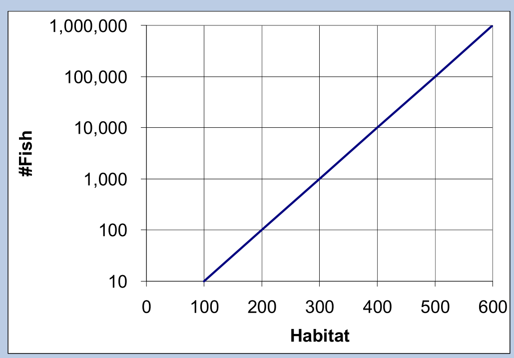

Figure 2. Causal Analysis.

While both figures show an increasing trend in the number of fish, Figure 2 illustrates a direct response in fish numbers given an increase in habitat area. Such causal analyses give management a stronger indication of the system controls.

substantially worse than those in the Trinity River. Will the difference in water quality occur during spring outmigration, especially in dry years? If so, how is this affecting smolt survival? What about other life stages?

8.4.4 Management Actions

The recommendations for management actions incorporate different schedules for flow releases under five defined water-year classes (determined by water-supply conditions measured each spring from mid-February through April). All year classes include a recommendation of high-flow releases in late April to mid-July and a program of gravel placement in the mainstem. These releases are recommended in addition to proposed riparian-berm-removal projects. The intent of riparian-berm-removal projects is to remove the densely vegetated riparian berms at selected sites along the river from Lewiston Dam downstream to the North Fork confluence.

Different April-July flow-release schedules are proposed for Normal, Wet, and Extremely Wet years such that in 6 out of 10 years the channel is predicted to change in cross section and planform. The goal is a meandering alternate bar configuration within the old floodplain. These water-year classes, each with unique hydrograph components, provide the inter-annual variability necessary to affect fluvial processes. A rehabilitated channel, although smaller in scale than the pre-TRD channel, could sustain perhaps two to four times the amount of salmonid rearing habitat now present. Results from SALMOD suggest that young-of-year production can be substantially increased if the rehabilitated channel attains a four-fold increase in the total available rearing habitat throughout the 40-mile reach below Lewiston Dam, all other things being equal (same average ocean survival and number of returning spawners and no further degradation of water quality, etc.).

The current recommendations were made in part, based on microhabitat studies in the existing channel. The existing baseline conditions can be quantitatively expressed as historical time series starting with streamflow and reservoir release records. The resulting hydrologic time series is input for SNTEMP (Theurer et al., 1984), PHABSIM (Milhous et al., 1989), and the Time Series Library (TSLIB) (Milhous et al., 1990) to produce a weekly estimate of the total usable habitat available throughout the study segment. The habitat time series is input to the SALMOD (Bartholow et. al., 1999) to produce a weekly time series of salmonid production estimates. This includes estimates of growth, downstream distribution, and number exiting the study segment.

Although the habitat-response hypotheses could be tested using the one-dimensional hydraulic and habitat models within PHABSIM, an alternative now exists. This alternative utilizes two-dimensional hydraulic models that provide major advancements in riverine habitat assessments. Many in the instream-flow-modeling community believe that two-dimensional hydraulic models are superior to their one-dimensional counterparts for simulating velocity distribution throughout river channel reaches (Ghanem et al., 1994; Leclerc et al., 1995). These advantages are particularly evident in complex river channels of the type it is hypothesized that the Trinity River will become as a result of the proposed management. These models are spatially explicit, allowing calculation of different measures of habitat environmental heterogeneity, and offer the potential to describe both spatial and temporal heterogeneity, in a single habitat metric. This new technology is recommended for evaluating habitat response to the proposed Trinity River AEAM actions.

8.4.5 Implement Actions

The AEAM program (see Section 8.4.2) will initiate its yearly cycle by convening each year in mid-February following initial water-supply forecasts provided by

Reclamation. Along with its other duties, the objective of the AEAM Program is to prescribe the precise magnitude and duration of reservoir releases confirming or modifying the OCAP for that year. These releases are based on the recommendations provided earlier in this chapter as well as other relevant information. The goals of the release schedule include mobilizing alluvial features established the previous year, scouring emergent riparian vegetation, and achieving sediment transport. Physical process modeling will aid the team in optimizing the reservoir release necessary to mobilize alluvial features and optimize lateral bank cutting. After the water year has been declared by Reclamation, these physical process models can simulate the remainder of the water year based upon the OCAP.

The degree of channel change can then be projected using the HEC-6 or other physical process models that predict aggradation or degradation of the channel. Kondolf and Micheli (1995) present a protocol for documenting changes in channel form. Reservoir release temperatures, downstream water temperature, usable habitat, and young-of-year chinook salmon production are all then simulated using the assumed reservoir release schedule and the physical model predicted channel changes. Annual estimates of returning adult chinook salmon spawners and the habitat state during the previous fall are important inputs to these simulations. Therefore, each annual production run is based on the latest empirical data (September-May) and simulated conditions for the remainder of the biological year (May-July).

8.4.6 Monitoring Program

Physical process numerical models are useful in two ways. First they require a systematic collection of data inputs. A well-designed monitoring program will yield the correct type, quality, quantity, and frequency of data. Second, they indicate where significant physical changes may occur, serving to focus monitoring activity in new, and perhaps unexpected, locations.

For example, the run mesohabitat type currently dominates the river above Dutch Creek. These runs are generally long and straight, confined by riparian berms on both sides. At the targeted rehabilitation sites, the removal of the riparian berm on one side of the river and the implementation of the prescribed flow regimes should produce alternate bar morphology with adjacent pools as is described in Section 4.1 of this report. Besides these major mesohabitat features, it is expected that additional mesohabitat types will also result, such as backwaters and riffle-pool transitional habitats. The number of different mesohabitat types and the proportion each represents should change significantly over current conditions, as should the range of hydraulic conditions present.

The annual evaluation of habitat changes at the mesohabitat level is straightforward. The types of pre-project mesohabitats present, the area each encompasses, and the proportion each represents in the reach will be compared with conditions in the previous year. A more detailed evaluation of habitat diversity is needed at the microhabitat scale.

The premise is that all habitat types are potentially important to the health of the anadromous salmonid community. Therefore, the monitoring objective is to quantitatively describe the mix of heterogeneous microhabitat types without regard to which species or life stage may or may not use a particular type. This is done by defining discrete, non-overlapping combinations of microhabitat characteristics and treating these in the same manner as individual species in developing community metrics.

Bain and Boltz (1989) introduced the concept of developing habitat suitability criteria to define habitat use guilds. The same concept can be applied to defining microhabitat types. For example, depth can be classified as shallow, moderate, or deep; likewise, velocities can be partitioned into slow, medium, and fast classifications; cover could be designated by function (e.g., velocity shelter) or simply by presence or absence. Illustrated in Table 8.12 is an example set of divisions that could be

Table 8.12. Example divisions of velocity, depth, and cover to delineate microhabitat types for habitat diversity hypothesis testing.

Microhabitat Attribute	Classification	Range
Velocity	Slow	0.0 - 1.0 fps
	Moderate	1.01 - 2.0 fps
	Fast	2.01 - 4.0 fps
Depth	Shallow	0.1 - 1.0 ft
	Moderate	1.1 - 3.0 ft
	Deep	3.1 - 6.0 ft
Cover	Present	Present
	Absent	Absent

used to delineate sub-classes of variables. Each of the 18 combinations describes a unique microhabitat type (e.g. shallow, slow, no cover).

Because each combination of habitat attributes is unique, it can be treated much the same as a species in traditional community ecology. Thus, for a given streamflow, one could derive values for habitat richness (the number of unique microhabitat types present), habitat diversity (an index of the heterogeneity among microhabitat types present), and habitat evenness (the ratio between calculated microhabitat diversity and the maximum microhabitat diversity possible).

The habitat diversity-discharge relations, displayed graphically, will allow comparative evaluations to determine if microhabitat diversity is increasing in the rehabilitation reaches. These relations will also provide insight into the stability of microhabitat diversity. That would be an indicator of the constancy in abundance of diverse microhabitat conditions as stream discharge changes. A time series analysis will show the temporal variability of habitat diversity. Using the habitat diversity-discharge function and a hydrologic time series, an annual chronology of habitat diversity could be evaluated.

On an annual basis assess the abundance and health (size, growth, diseases, ATPase activity) of smolts utilizing cooler water-temperature conditions. Fish samples for measurement using rotary screw-taps or other capture techniques, at key locations (upper Trinity River, lower Trinity River, and near the estuary), could be taken. On a longer time scale, use adult returns as a measure of success.

Under controlled and natural settings, examine how water temperature affects smoltification of Trinity River parr and smolts. There may also be a need to examine the effects of low dissolved oxygen concentrations on parr and smolts, particularly during Dry and Critically Dry years.

8.4.7 Compare Predictions versus Observations

During early winter, model simulations are run again using the actual preceding 12 months of flow releases and downstream tributary inflows. Seldom do meteorological and precipitation patterns follow seasonal patterns exactly as in the past. Therefore, the physical process and biological models are more fairly tested by comparing outputs (predictions) based on actual (as near as they can be determined) streamflow distribution through the river

An Example

The Stream Network Temperature model (SNTEMP) predicts temperatures in the mainstem of the Trinity River at various points downstream of Lewiston Dam. Inputs into SNTEMP include meteorological data, mainstem and tributary flow rates, and outflow temperatures from Lewiston Dam. The output from SNTEMP is useful in determining if the temperature of the mainstem is within the desirable range for optimal growth rates and outmigration (smoltification) of anadromous fish.

As a water year progresses, management will monitor meteorological and other data prescribed by the monitoring program. In a cooler than average year, the flow in the mainstem will warm slowly compared to an average or warm year. Much of the flow in the late spring and early summer is necessary to maintain desirable temperatures in the mainstem. Meteorological and flow data, processed by the SNTEMP and other models, will reflect the cooler temperature in the mainstem. If predicted temperatures are below the desirable range, then reducing flow should continue to meet temperature requirements. Realizing efficient flow management is a matter of combining predictive models with a directed monitoring program.

segment. Habitat and salmonid production outputs are compared with measured channel form, smolt growth, and production.

8.4.8 Restate System Status

The system state and the degree of progress toward the stated management objectives are determined by comparison with the previous year's observations.

8.4.9 Adapt and Modify Actions as Needed

Scientific evidence is presented to the managers and stakeholders in support of or refuting the original hypotheses. Scientists revisit the hypotheses (or develop new hypotheses if originals are rejected) and recalibrate models awaiting the next round of forecasts, decisions, and simulations. If certain hypotheses are rejected or alternatives are proposed, alternate flow releases or other management actions are designed (within the bounds of the annual water year volume) and submitted to management prior to the winter-spring forecast period. Table 8.13 lists the models and the monitoring-data needs as described for the Trinity River.

8.5 Roles and Responsibilities

Implementation of the AEAMP is critical to the success of the Trinity River fishery restoration and maintenance effort. The authors recognize that all views of stakeholders should be considered in designing an implementation program. Our underlying principles are that "best science" underpin yearly and within-year operating decisions and that all Trinity River AEAM Program activities would comply with applicable laws and permitting requirements. Additionally, independent review must be consistent and panels would provide peer review of all technical studies, analyses, and evaluations generated by the program.

The program would be directed by the Secretary through a designee, who would serve as the principal contact for the AEAM and as the focal point for issues and decisions

Table 8.13. Data, techniques, and models for interdisciplinary analyses.

	Geomorphology	Sedimentation	Temperature	Fish Population	Water Supply	Riparian Vegetation	Dam Safety	Inundation
Data	Bar structure Bar mobilization Bar migration Berm/riparian destruction	X-section & aerial gradations Transport by size fraction Fate: scour/fill	Reservoir boundary condition	Number of spawners Presmolt outmigration Spawning locations Size of outmigrations Rearing habitat	Annual forecast January through May	Density Age Type Germination	Encroachment on rule curve envelope	Water stage recorders Bridges Urban encroachment
Techniques	Annual videography Ground Survey Aerial topography X-section at reference sites Longitudinal water surface & bed profiles Particle size fractions Gradations	Bed load/suspended load Discharge recording Tributary measurements Particle size fractions Gradations	Width/depth Shade Temperature recording Tributary measurements	Estimates of escapement and smolt production Estimates of useable habitat area		Seedling counts Ground survey	Rule curve operational limitations	
Models	HEC-2 (HEC-RAS) HEC-6	HEC-6	SNTEMP BETTER WQRRS	SALMOD	Empirical Forecast PROSIM TRNMOD	Vegetation establishment model, Mahoney and Rood (1998)	DMBRK/ BREACH FLDWAV PROSIM	HEC-2 (HEC-RAS)
Simulation Predictions	Areas of bars/pools by reach	Scour and fill Gravel quality	Longitudinal profile Forecast time series	Weekly number and size leaving specific areas	Updated biweekly	Area of bars w/seedlings Durability by reach	Storage volume Reservoir elevation Number of encroachment events	Flood levels and duration downstream of Trinity

associated with the program. His/her responsibility would include ensuring that the Department of the Interior fulfills its obligations to restore and maintain the Trinity River Fishery.

Components of the Trinity AEAMP include a Trinity Management Council (TMC) supported by a Technical Modeling and Analysis Team (TMAT) and a rotating Scientific Advisory Board (SAB). The program would include consultation with other agencies and interested groups through periodic interaction through a Stakeholders Group. Scientific credibility would be assured through external peer review of operating plans, models, sampling designs, and projections as outlined in Figure 8.19. The general roles and responsibilities of these groups are summarized below.

8.5.1 Trinity Management Council

The TMC would be composed of fishery agency representatives. The Secretary's designee would serve as Executive Director. The TMC would approve fishery restoration plans and any proposed changes to annual operating schedules (described earlier in this chapter) submitted by the Technical Modeling and Analysis Team (see Section 8.5.2). The TMC would be the focal point for issues and decisions associated with the program. The Executive Director's responsibilities would include ensuring that the Department of the Interior fulfills its obligations for streamflow releases and rehabilitation of the river corridor habitats. The Executive Director in consultation with the Council members would review, modify, accept, or remand the recommendations from the TMAT in making decisions about any changes in reservoir releases, dam operations, and other management actions.

8.5.2 Technical Modeling and Analysis Team

The TMAT would consist of a permanent group of 4 to 8 scientists selected to represent the interdisciplinary nature of the decision process. Collectively, they must possess the skills and knowledge of several disciplines: water resources, engineering, geomorphology, water quality, fish population biology, riparian ecology, computer modeling, and data management. Depending upon the number of individuals selected and possible related duties, they may be assigned from 50 to 100 percent time to the TMAT. The TMAT responsibilities include design for data collection, methodology, analyses, modeling, predictions, and evaluating hypotheses and model improvements. This Team would have delegated from the Executive Director a budget and the responsibility for preparing requests for proposals (RFP) to conduct specialized data collections for model input and validation. Spatial coverage and sampling designs for long-term monitoring for status and trends would be developed in consultation with the management agencies and specific recommendations made to the TMC for funding. Funding for the long-term monitoring would remain with the TMC.

8.5.3 Scientific Advisory Board

The SAB would be appointed by the Executive Director. This group would be composed of prominent scientists appointed and appropriately compensated for 2 to 3 year

> "A riverine ecosystem perspective accurately describes the intent to improve anadromous salmonid habitat . . . . [and] to promote alluvial riverine characteristics . . . . These recommendations are intended to shift the ecological role of the mainstem below Lewiston Dam toward one that will provide the habitats necessary to restore the fishery resources of the Trinity River."

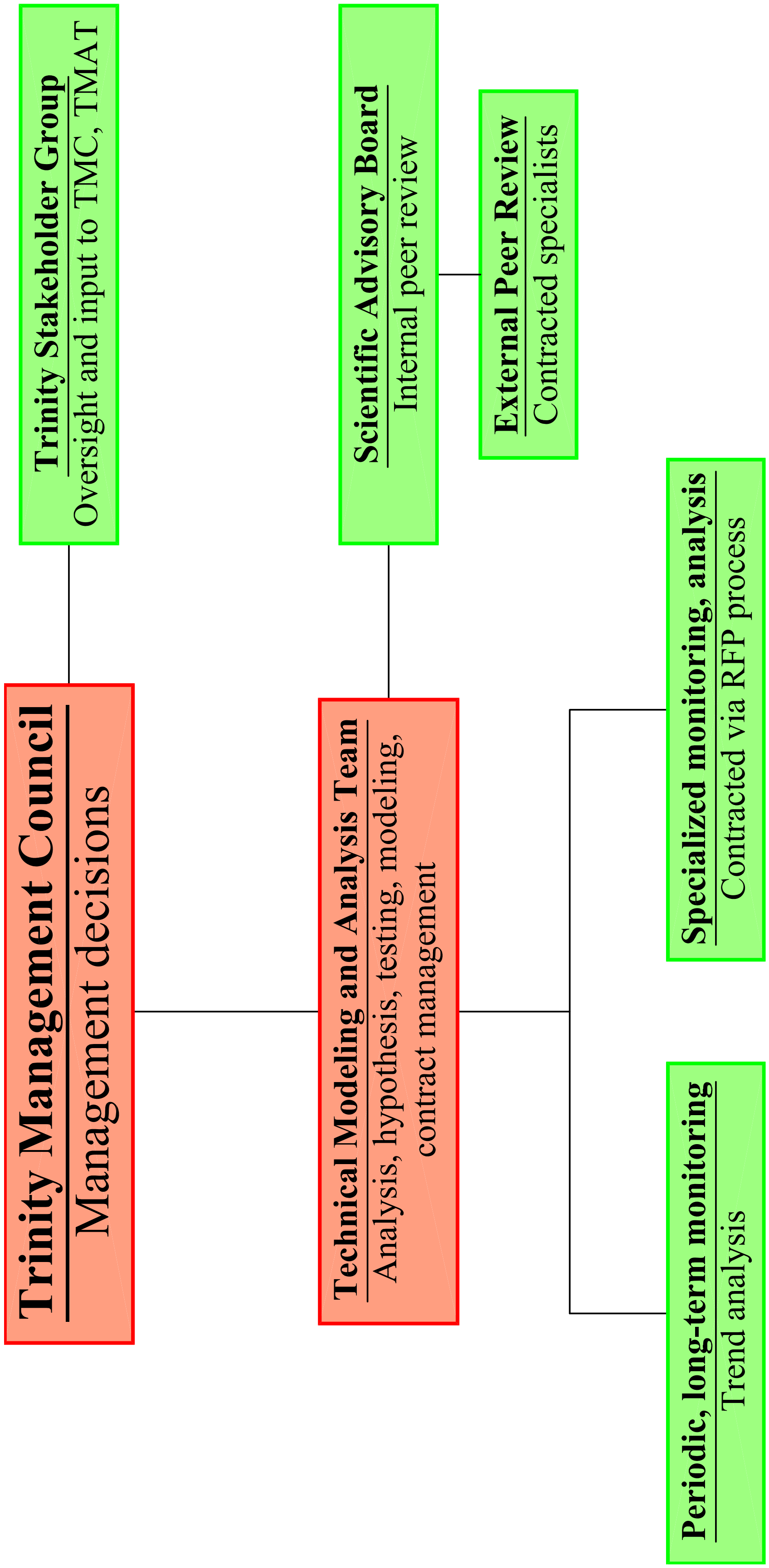

Figure 8.19. Organizational components of a successful Adaptive Environmental Assessment and Management (AEAM) program.

rotating terms. The SAB would be responsible for semiannual review of the analyses, models, and projections of the TMAT as well as providing a science review of the overall management plans and implementation of the annual operating criteria and procedures (described earlier in this chapter) as directed by the TMC. The SAB would also select outside peer reviewers and conduct the review and selection process for any contracted data collection, research, or model development.

8.6 Summary

Allowing the Trinity River to resume its alluvial nature through the integration of increased instream releases, fine and coarse sediment management, and mechanical channel alteration is necessary to restore its anadromous salmonid fishery resources. A riverine ecosystem perspective accurately describes the intent to improve anadromous salmonid habitat in the mainstem by managing releases from Lewiston Dam and supplementing coarse sediment in the mainstem to promote alluvial riverine characteristics in conjunction with flow and sediment inputs from unregulated tributaries.

These recommendations do not target the pre-TRD mainstem as its restoration goal because physical constraints imposed by the TRD cannot be entirely overcome; the primary constraints being the elimination of coarse sediment recruitment from the Basin above Lewiston Dam and the elimination of winter floods. A shift in the mainstem's ecological role occurred the first year of TRD operations to the detriment of the fishery resources of the river. These recommendations are intended to shift the ecological role of the mainstem below Lewiston Dam toward one that will provide the habitats necessary to restore and maintain the fishery resources of the Trinity River.

As the recommendations are implemented, it will be imperative to monitor their success and modify management actions in response to information gained during implementation. To this end, an Adaptive Environmental Assessment and Management (AEAM) program is recommended that is tailored to refine actions consistent with the flow requirement recommendations.